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VOLUME XXV SAN FRANCISCO, NOVEMBER 19, 1910. NUMBER 21

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THE INDUCTION MOTOR AND GENERATOR[1]

BY F. G. BAUM.

(Note: This paper practically as it stands was prepared for University students about 1902. On account of the interest in the induction generator and to answer a number of questions, the paper is now published. F. G. B.)

The theory of the induction motor and generator, as we shall see, is practically the theory of the alternating current transformer with open magnetic circuits, that is, a transformer possessing considerable magnetic leakage. We will take up the theory graphically, developing the circle diagram. I believe, with this diagram, one can gain a working theory and see the physical relations much more easily than were the subject treated analytically. After thoroughly understanding the graphical theory one will find no great difficulty in understanding the analytical theory as given by Mr. Steinmetz. The theory as here given is essentially that given by Mr. B. A. Behrend, Mr. Heyland and others, except that the development of the circle diagram as generally given is simplified.

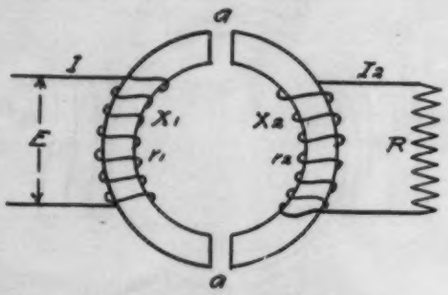

Fig. 1. Transformer With Large Magnetic Leakage.

Let us consider a transformer with air gaps a a (Fig. 1) in the magnetic circuit and therefore having a large magnetizing current and large magnetic leakage. The transformer may be considered as having a ratio of transformation of 1 to 1. This transformer for our purposes may be replaced by the equivalent electrical system shown in Fig. 2. Here we have shunted across the potential E a coil taking the magnetizing current of the transformer, I_0. That is, if the secondary resistance R were opened we would obtain the same primary line conditions, namely, the primary current and power factor would be the same, with the circuit in Fig. 2, as with the transformer in Fig. 1. If, now, R has a given value, in Fig. 2 and Fig. 1, not infinity, the reactance X, (equals $X_1 + X_2$ in Fig 2) would be so adjusted that we again obtain the same primary current at the same power factor for each case.

Practically X_0 would be measured by open circuiting the secondary and taking the ratio of E / I_0, that is $X_0 = E / I_0$, practically.

The current I_0 is nearly wattless, since the only losses are those due to hysteresis and the primary copper loss. In Fig. 3 we have laid off $E = oa$, the pressure applied to the transformer and have laid off $I_0 = ac$, making an angle of θ_0 with E, as determined by the power factor. By projecting the point O on the I_0 line we obtain the e.m.f. triangle o b a, in which $ab = I_0 R_1$. R_1 being the effective resistance; that is $I_0^2 R_1$ equals the total watt loss due to copper and iron when the secondary of the transformer is on open circuit. A more accurate value of X_0 may be obtained by dividing o b by I_0.

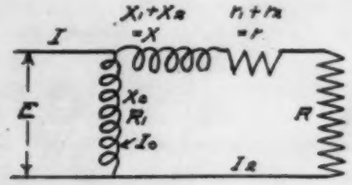

Fig. 2. Electrically Equivalent to Fig. 1.

The primary open circuit current which we would get if there were no losses may be found by drawing a line at right angles to I_0 at the point c, and obtaining the length a c' ad being at right angles to E. There is, however, little difference between I_0 and I_∞.

To determine $X = X_1 + X_2$, the equivalent reactance of the transformer, the secondary resistance R is short-circuited and the primary current and power factor of the circuits in Fig. 1 again read. Then we would adjust the reactance X in Fig. 2, until with

[1] A paper presented at the San Francisco Section of the American Institute of Electrical Engineers, Nov. 18, 1910.

R = o we again obtain the same value of the primary current and power factor. In Fig. 4 a c is the open circuit current and $a d_1 = I$, is the primary current in magnitude and direction when R = o. The primary power factor gives us the value of θ. The current $c d_1 = I_2$ is not exactly the current in the secondary, but

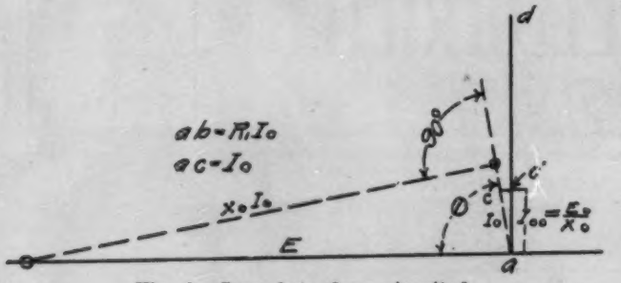

Fig. 3. Secondary Open-circuited.

represents the primary current corresponding. It will, however, be taken to represent the secondary current or the corresponding primary current. If it were not for the internal resistance of primary and secondary. I_2 would increase to the value of $c d = E / X$. This length is obtained by drawing a line at right angles to c d, at d, until it intersects the line c d drawn at right angles to E. The equivalent reactance, X, then, is obtained by dividing E by c d in amperes. If the secondary resistance R is varied from a short circuit

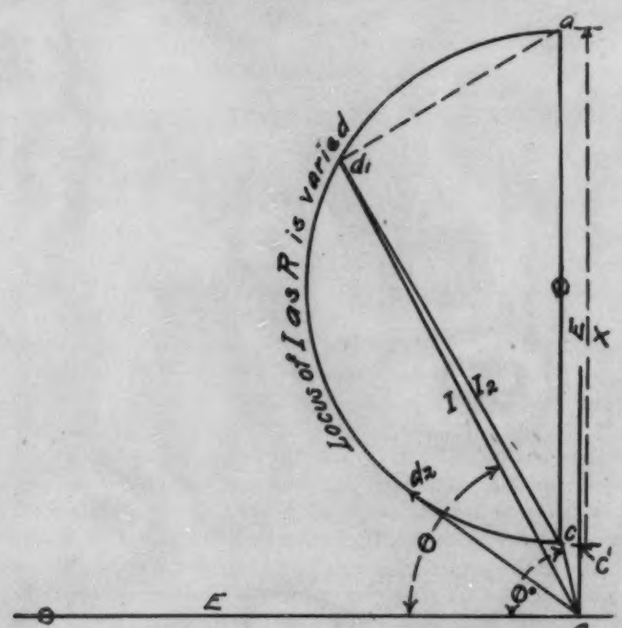

Fig. 4. Showing Locus of Primary Current as R is Varied.

to an open circuit, the locus of I will be the circumference of the circle $c d_2 d_1$. It should be noticed that to entirely determine the locus of I it is only necessary to measure the primary current I_0, the short circuit current I and the power factors θ and θ_0 corresponding to I and I_0. The same will be found true of the induction motor. As E is constant and $X = X_1 + X_2$ is assumed a constant, and we know $I_2 r$ and $I_2 X$ are at right angles to each other, it follows that I_2 follows the circular arc $c d_2 d_1$.

In a closed circuit transformer c d is very large compared to a c. Assuming the full load current to be 50 times the open circuit current and the reactance pressure (= X times full load current) of the transformer to be 5 per cent of the full voltage, c d would be 1000 times a c. In an open circuit transformer, however, c d may be only 10 to 50 times a c. Hence we shall see that the main difference between the theory of the closed circuit transformer and the induction motor or generator is due to the difference in the ratio of the short circuit to the open circuit current, and that the diagram of the induction motor is the same as Fig. 4 for the open circuit transformer.

The Induction Motor.

In the induction motor we have a primary and secondary circuit always in inductive relation to each other as in the transformer, the only change being that the secondary generally is in motion, and this fact confuses the relations and reactions. Before applying the above theory of the transformer to the induction motor one should first clearly see that so far as the reaction of the secondary current on the primary is concerned, the secondary could be stationary.

To show this we must consider the rotating field produced by the primary. This field is produced by coils carrying currents differing in phase, the coils being spaced angularly to correspond with the phase displacement in time of the currents in the coil. For a two-phase motor, the winding may be represented

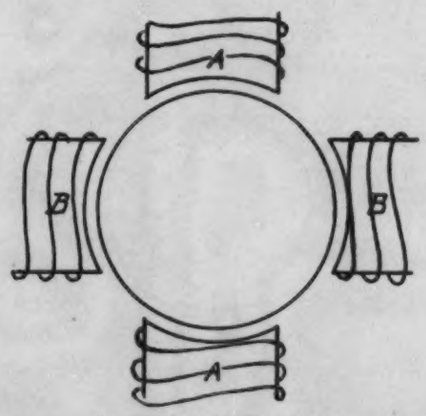

Fig. 5. Two-phase Motor.

diagrammatically as in Fig. 5, coils carrying two-phase currents being placed as shown, would produce near the center a rotating field of constant magnitude, the frequency of rotation being equal (for the case shown) to the periodicity of the alternating current.

Fig. 6 shows a three-phase motor diagrammatically. In order to reduce the speed of the motor, the poles may be increased. Doubling the number of poles reduces the speed to one-half. In practice the coils are not wound on inwardly projecting poles as shown but in slots as in Fig. 7. The air gap is small and is the same all around the circumference of the armature. In America, open slots are generally used. The armature, or rotating part, of the induction motor practically consists of a structure built up of iron lami- The armature, or rotating part, of the induction motor practically consists of a structure built

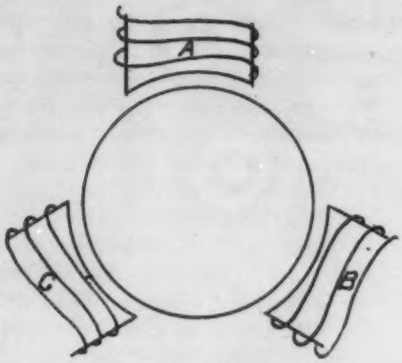

Fig. 6. Three-phase Motor.

up of iron laminations with short circuited bars of copper running from front to back. Although a two or three phase current will not produce an absolutely constant rotating field, yet for practical purposes the field may be considered constant. A rotating field being produced by the primary there will be induced currents in the secondary (the secondary is the rotating armature). When the secondary is at a standstill we have simply a transformer action, the frequency of the secondary

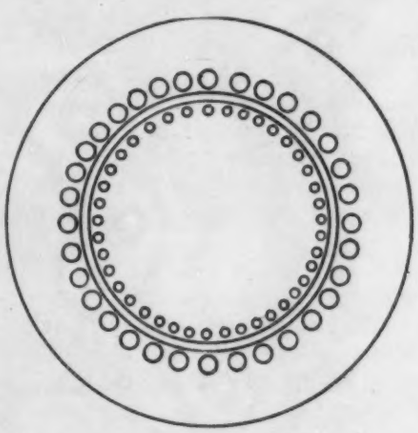

Fig. 7a. Armature and Rotor With Closed Slots. In the United States open slots are generally used.

induced currents being equal to the primary frequency. The primary rotating field will, as may be easily seen, tend to pull the rotating armature after it. Suppose the primary field to rotate at an angular velocity w, and the motor armature to follow at an angular velocity of w_2. The relative motion between the primary field and secondary will then be $w_1 - w_2 = w$, the angular velocity of the "slip," the slip being defined as the ratio $\frac{w_1 - w_2}{w_1} = \frac{w}{w_1} = s$. The e. m. f. and therefore the current in the secondary will have a frequency w, since the rotating field cuts the rotating armature conductors at the angular velocity w. The current induced in the secondary produces a rotating field, the frequency of rotation relatively to the primary being w. But the armature is rotating at an angular velocity w_2 so that the field set up by the secondary is rotating relatively to the primary at a frequency $w_2 + w$. But this is equal to w_1. That is, in its reactive effect on the primary, the secondary current may be considered of the primary frequency w_1.

The frequency of the secondary current being w, the reactive pressure consumed in the secondary decreases in the ratio $w / w_1 = s$, as the "slip" decreases; that is, as the speed of the motor increases the reactive pressure consumed by the secondary decreases. With the armature at standstill, the reactive pressure is $X_2 I_2$; at a "slip" s the reactive pressure would be $sX_2 I_2$, X_2 being the reactance at full frequency, that is, at standstill.

In order to apply the circle diagram to the induction motor, that is to prove that the locus of the

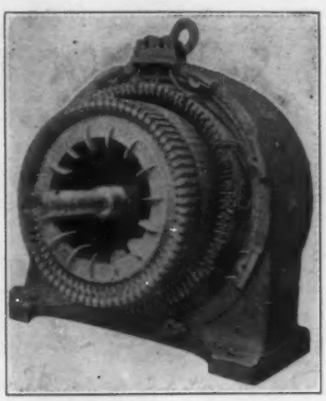

Fig. 7b. Three-Phase Induction Motor, End Bell Removed.

secondary current is a circular arc, it remains to show that a change in speed of the armature is equivalent to a change of resistance R in the secondary of the stationary transformer (Fig. 1).

As in the case of the transformer, we will consider the ratio of transformation between primary and secondary at 1 to 1. Suppose the armature to rotate at an angular velocity w_2, the slip between the rotating field and armature being s. An induced e.m.f. e in the primary then gives an induced e.m.f. se, equals ai (Fig. 8) in the secondary. At standstill $s = 1$, the primary and secondary induced pressures are practically equal; if w_2 were equal to w_1, s would be zero, and the induced e.m.f. in the secondary would be zero. At any slip s we then have the induced pressure se consumed by the current I_2 flowing over the resistance r_2 and the reactance sX_2. These three pressures se, $I_2 r_2$ and $s I_2 X_2$ form a right angled triangle ahi (Fig. 8).

The current in the armature is

$$I_2 = \frac{s e}{\sqrt{r_2^2 + (sX_2)^2}} = \frac{e}{\sqrt{\left(\frac{r_2}{s}\right)^2 + X_2^2}}$$

and we see at once that I_2 is the locus of a circle having $\frac{r_2}{s}$ as a diameter and the current in the armature is the

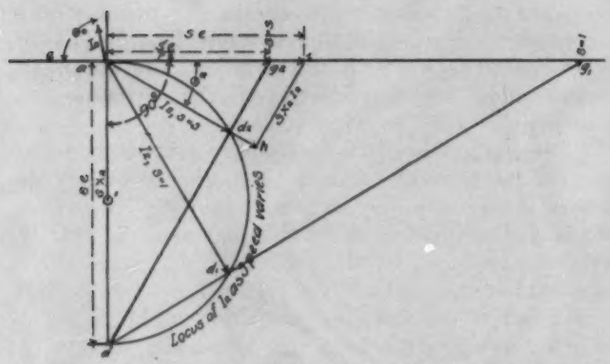

Fig. 8. Current in Armature of Induction Motor.

Note—Fig. 8 shows the current and pressure relations in the secondary and are shown in the lower right-hand quadrant; the corresponding primary relations are drawn in the upper left hand quadrant, Fig. 9.

same as though the armature were held stationary and the resistance changed to $\frac{r_2}{s}$ (See Fig. 8).

To represent what takes place in the primary we draw Fig. 9, which is similar to Fig. 4 for the case of

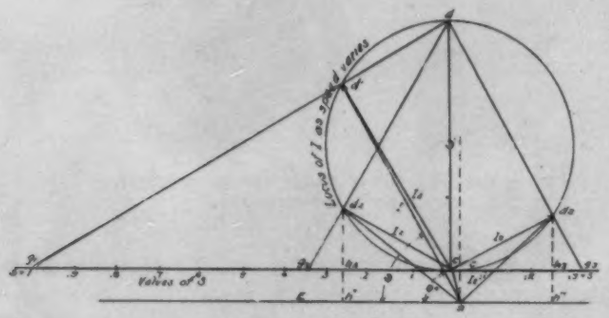

Fig. 9. Circle Diagram, Theoretical.

the transformer. We may substitute E the impressed pressure at the terminals in place of the induced pressure e without serious error. The primary current I is determined by combining I_0 and I_2. It must be remembered that I_2, the true secondary current cannot generally be measured; the I_2, then, in Fig 9 is the primary current corresponding, and is drawn directly opposite to the true direction of the secondary current.

Heretofore the secondary induced pressure was assumed to be fixed in value. This compels the primary impressed pressure to exceed such secondary induced pressure by an amount equal to the pressure lost in the primary impedence. Since the pressure thus lost may be expressed by components in phase and in quadrature with the secondary the same as the secondary induced pressure, the total primary impressed pressure which is the sum of these two pressures may also be so expressed. The circle diagram will, therefore, give the relation between the secondary current and a fixed primary impressed pressure. The two circles, one for the secondary induced pressure fixed and the other for the impressed primary pressure fixed have common locations for their diameters, both terminating at c and differing only slightly in magnitude.

To determine the circle diagram in a practical case we proceed as follows: (1) Run the motor without load and measure I_0 and θ_0 and lay these off to scale (Fig. 10); (2) with the motor at standstill we must determine the starting current ad, and the angle θ. The length ad_1 must be determined with the resistance in the armature in running position. As this would give us too large a current at full e.m.f. applied the impressed e.m.f may be reduced and correction made for full voltage. To determine the diameter of the circle, then, a line $d_1 d$ is drawn at right angles to cd_1 giving cd. The circle may now be drawn. If in Fig. 8 we extend the lines dd_1 and dd_2 until they intersect the line se produced we obtain lengths g_1c and g_2c, which are proportional to the slip of the motor. In Fig. 9, having drawn dd_1 g_1 we may divide the length cg_1 into ten equal parts corresponding to .1, .2, etc., of the slip. The current for any particular value of the slip may be obtained by joining the desired point along cg_1 with the point d. For example when the slip is .33, the armature is cd_3 and the primary current ad_3, Fig. 9.

The power absorbed by the primary is proportional to ah''' or $c'h_2$, and the power transferred to the secondary is practically (primary copper loss must be subtracted) proportional to ch_2. cc' is proportional to the primary input at no load, which includes the mechanical losses, as well as the electrical. cd does not represent the true position of the diameter of the circle, as ac is not the current we would get without the windage and friction of the motor. The value of I_0 will practically not be affected, but θ_0 will be larger which will move c nearer c'. The point c is, therefore, not the true point for $s = o$, that is synchronous speed, but $s = O$ is somewhere between c and c'. The error made, however, in taking c as the point is small and may be corrected by first determining the point c and then separating the electrical and mechanical losses and dividing $c\,c'$ in proportion, the exact position of the diameter of the circle cd may be found. The length cc' should only represent the electrical losses at $s = o$.

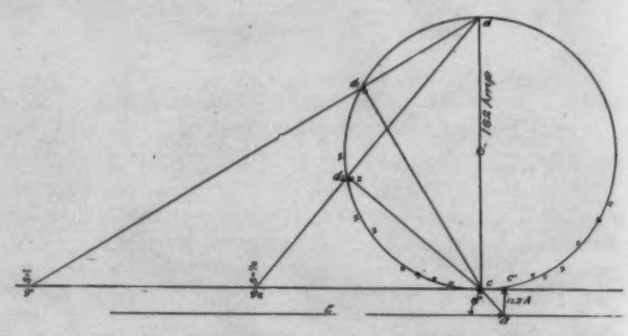

Fig. 10. Diagram for 10-h.p. Induction Motor.

Fig. 10 shows the curve actually obtained from a 10 h.p. two-phase, 200-volt, squirrel cage armature induction motor. ac is 11.3 amperes and cd is 162 amperes. The starting current at full voltage is cd_1.

By a study of this simple diagram, I believe one will get a clearer idea of the induction motor and generator than in any other way. The theory, as pointed out, is not absolutely accurate, but for practical pur-

poses it serves very well. As shown, when developing Fig. 8, we should consider quantities in the secondary, but, as those ordinarily cannot be measured, we must use primary quantities to express what takes place in the secondary.

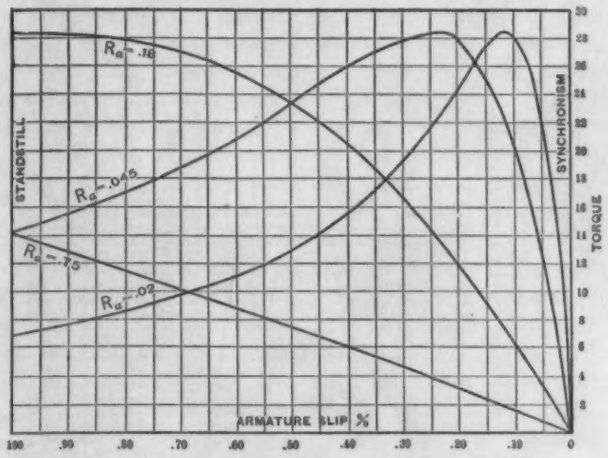

Fig. 11. Showing Dependence of Torque on Slip and Resistance.

The Torque of the Motor.

The secondary input at any slip s is

$$K\ W_2 = e\ I_2 \cos\theta_2;\ \text{but}\ \cos\theta_2 = \frac{r_2\ I_2}{s\ e};\qquad (1a)$$

$$\text{therefore}\ K\ W_2 = I_2^2\ \frac{r_2}{s} = \frac{\text{secondary copper loss}}{\text{slip}}\qquad (1b)$$

The secondary output, or the mechanical power developed is equal to back e.m.f. times I_2 times $\cos\theta_2$. That is,

$$\text{Output} = e\ (1-s)\ I_2 \cos\theta_2 = I_2^2\ r_2\ \frac{1-s}{s} = I_2^2\ r_2\ \frac{w_2}{w}$$

Expressing this as equal to torque, T times the angular velocity of the motor we get

$$T w_2 = I_2^2\ r_2\ \frac{w_2}{w}\ \text{or}\ T = I_2^2\qquad (2)$$

But $w = s w_1$;

$$\text{Therefore}\ T = \frac{I_2^2\ r_2}{s\ w_1}\qquad (3a)$$

Combining with equation (1b) we see that

$$T = \frac{\text{secondary copper loss in watts}}{\text{synchronous speed} \times \text{slip}}$$

$$= \frac{\text{secondary input}}{\text{synchronous speed}}\qquad (3b)$$

The secondary input is sometimes called the Torque in synchronous watts, expressing the power in watts which the motor would develop for the same necessary input if it were running at synchronous speed.

To put the torque in equation (3b) in pounds at one foot radius and the synchronous speed in r.p.m. we must multiply the right-hand member by 33,000 and divide π by 2 times 746. This gives us

$$\text{T in pounds} = \frac{7.04\ \text{secondary input in watts,}}{\text{synchronous speed in r.p.m.}}\ \text{or}$$

$$T = \frac{7.04\ (\text{primary input} - \text{no load loss} - I_1^2\ r_1)}{\text{synchronous speed in r.p.m.}}$$

(practically)

From this equation and Fig. 10, we may construct a torque slip curve. We may determine with the circle diagram, as can be easily seen, the efficiency curve, the power factor and any other data desired for practical work. We see from Figs. 9 and 11 (see length ch, which is proportional to the secondary input, has a maximum value equal to the radius of the circle cd) that the maximum torque will be practically independent of the secondary resistance. If we increase r_2 we may move the starting current to any point between d_2 and c. In the type of motors using a resistance in the secondary in starting the starting current is made to fall below d_2, Fig. 9. As the motor comes up to speed then the resistance is cut out. The slip of induction motors varies from 1 per cent to 15 per cent according to size, decreasing as the size increases.

From equation (3a) the output in synchronous watts is $T w_1 = \frac{I_2^2\ (r_2)}{s} = \frac{\text{secondary copper loss}}{\text{slip}}$

Now $I_2^2 r_2$ represents the secondary copper loss, and, if we assume the primary copper losses equal to the

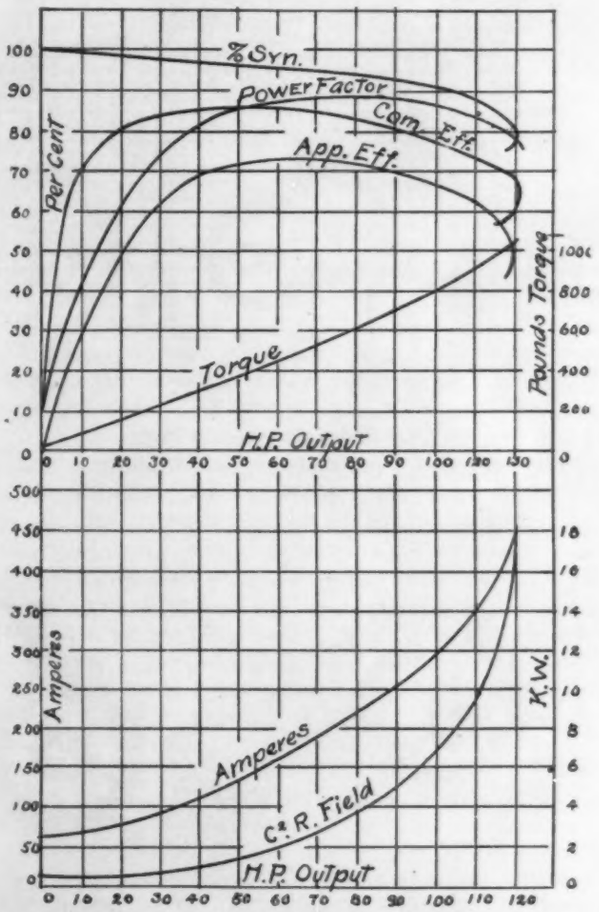

Fig. 12. Characteristics of 50-h.p. 220 Volt Motor.

secondary, then the total copper losses will be $2 I_2^2 r_2$. The other losses in the motor are the iron losses and the mechanical friction losses. If, for simplicity and for illustration, we take these again to equal the secondary copper losses, the efficiency of the motor would be

$$Ef = \frac{\text{Secondary Output}}{\text{Primary Input}} = \frac{\frac{I_2^2 r_2}{s}}{3 I_2^2 r_2 + \frac{I_2^2 r_2}{s}} = \frac{1}{3s + 1} \quad (4)$$

If $s = \frac{1}{20} = 5$ per cent slip,

Then $Ef = \frac{1}{0.15 + 1} = \frac{1}{1.15} = 87$ per cent.

Equations 3a and 4 show the importance of slip on the efficiency, and 3a also shows that low secondary resistance is necessary for small slip.

Fig. 12 gives the characteristics of a 50 h.p. motor.

Fig. 13 gives the characteristics of a 2000 h.p., 6600-volt induction motor.

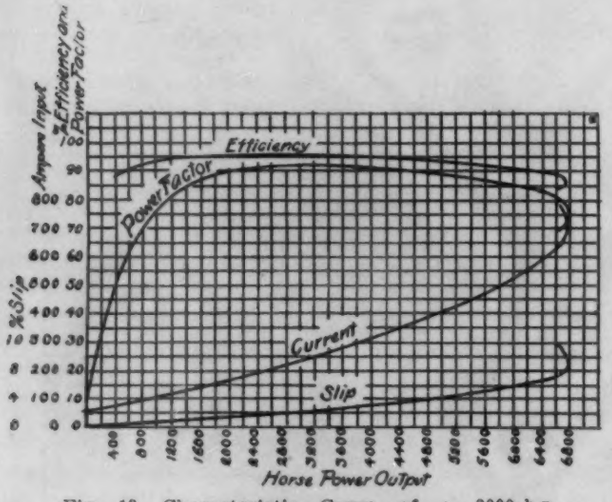

Fig. 13. Characteristic Curve of a 2000-h.p., 234 r.p.m., 6600 Volt Induction Motor.

The Induction Generator.

It will be at once seen that if the slip is made negative—that is, if the rotor of the motor be driven above synchronism, the e.m.f. generated by the rotor will reverse; that is, it would then require power to drive the rotor and in this case the induction motor becomes an induction generator. The points shown to the right of c^1—Fig. 10—were obtained by driving the rotor above speed and measuring the current and power factor of the outgoing current. The current in the armature will again be

$$I_2 = \frac{s e}{\sqrt{r_2^2 + (s X_2)^2}} = \frac{e}{\sqrt{\frac{r_2^2}{s^2} + X_2^2}}$$

and the locus is on the circle as shown in Fig. 10. That is, from this figure one can determine the characteristics of the induction generator, and it will be seen that the characteristics of the induction generator are practically the same as those of the induction motor. In fact, by changing Fig. 13 so that the mechanical input gives the corresponding electrical output as to volts, amperes and power factor we obtain Fig. 14, which gives the characteristics of the induction generator.

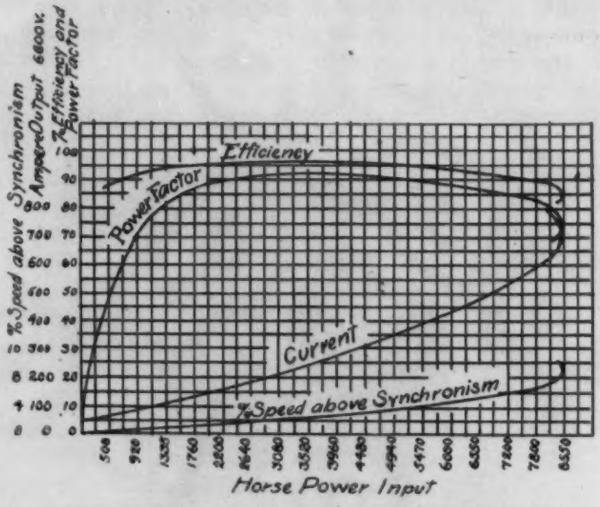

Fig. 14. Characteristic Curves of a 2200 h.p. 234 r.p.m. 6600 volt induction generator.

The induction generator cannot, of course, operate except in parallel with synchronous generators, and draws lagging current from the synchronous generators. The induction generator shown in Fig. 12 takes 30 per cent of full load current for excitation; as load is taken by the induction generator the power factor steadily improves.

The induction generator can have no effect in regulating the voltage of the system, and the regulation must be done by the synchronous machines. The induction generator generates power and the synchronous generator generates voltage. The disadvantages of induction generator is that it takes lagging current from the system for excitation and cannot help in regulating the voltage of the system. The advantages are, of course, that no exciter is necessary and the operation of the station is simplified. It is not necessary to synchronize; in fact, synchronizing is not possible. The station operator would, in starting, bring the generator up to near synchronous speed and close the switch, and then increase the speed of the unit until the desired load is obtained for the generator.

Fig. 14 shows what currents would be carried by the generator for given percentages of speed above synchronism.

If the unit should "run away" and the operator close the switch at maximum speed or any other speed, Fig. 14 will indicate the power which would be generated until the speed of the unit was brought to normal. The most dangerous point to close the switch would not be at maximum speed, but at the speed corresponding to maximum torque or maximum power generated. Closing the switch at this time might produce severe electrical and mechanical stresses, the con-

ditions being similar to throwing an induction motor on the line at full voltage without compensator or resistance; in fact, it will be noticed by an examination of Figs. 11, 12 and 13 that more sudden and severe strains will be thrown on an induction motor if it is connected to the line electrically when at some speed below synchronism, which gives a torque considerably larger than the torque at standstill. And, similarly, throwing the induction generator on the line when at some speed above synchronism will throw much more severe strain on the generator than there would be if the electric connections were made when the speed of the generator was about double synchronous speed.

Three-phase Induction Generator in Interborough Rapid Transit Plant, New York.

It should also be noticed that in throwing the induction generator on the line it will take several cycles for the induction generator field to come into proper interphase relation with the primary field, and hence, for several cycles there will be severe current rushes, which, however, should do no harm provided the electrical construction of the generator is substantial.

The field of application for the induction generator is limited to certain special cases, where the proportion of the total capacity would not be large. It has some advantages in large power stations in addition to its simplicity in limiting the surge voltage in switching, etc. However, a careful study of conditions should be made before installing induction generators, and they should not be installed, as were a few 25-cycle plants a few years ago, because some one else had done the same thing.

"ANY OLD KETTLE WILL MAKE STEAM."

BY R. N. MILLER.[1]

Everybody knows that. Where is the little boy who has not found it out for himself, while watching the kettle boiling on the stove and trying to stop the steam from coming out by thrusting sticks into the spout, only to get his fingers burnt for his pains? But will any old kettle make steam to the satisfaction of the engineer of a modern steam-plant or steamship? No; the engineer is looking for the most economical steam generator that the market can produce.

Let us briefly trace some of the evolutions of the kettle. Let us see what necessity and requirements have brought forth in the steam generator of today.

The earliest boilers were made of copper flasks with an opening at the top to which a pipe was attached for leading off the steam; such boilers were placed over an open fire. The steam generated by them was used by the ancients as early as 120 years before the Christian era to serve purposes of superstitious worship.

The first boiler to generate steam for any practical purpose was designed in 1655 by the Marquis of Worcester, who wished to generate steam to raise water for domestic and irrigating purposes and for driving water from mines. Because he considered the thing practical he was looked upon as a mad enthusiast. An extract from the description of his invention shows what he claimed and gives some idea of what he had to contend with:

"Invention 68—An admirable, most forcible way to drive up water by fire; not drawing or sucking it upward, for that must be as the philosopher calleth it *'infra sphaeram activitatis,'* which is but at such a distance, but this way has no bounder, if the vessels be strong enough; for I have taken a piece of whole cannon, whereof the end was burst, and filled it three-quarters full, stopping and screwing up the broken end, as also the touch-hole, and making a constant fire under it; within twenty-four hours it burst and made a great crack; so that, having found a way to make my vessels so that they are strengthened by the force within them, and the one to fill after the other, I have seen the water run like a constant fountain forty feet high. One vessel of water rarefied by fire driveth up forty of cold water; and a man that attends the work is but to turn two cocks, that, one vessel of water being consumed, another begins to force and refill with cold water, and so successively."

The boiler designed by the Marquis was placed below the level of the water to be raised. His vessels, being filled by gravity, their contents were raised simply by the elastic force of the steam. He stated a measure of steam; one pound of steam would raise forty pounds of cold water.

Following the Marquis came Captain Thomas Savary, who raised water by means of the vacuum caused by condensed steam.

All early boilers were either globular or spherical, and were set upon an open fire. But that arrangement required an enormous quantity of fuel to produce a small quantity of steam. The boiler was heated, and so also was every surrounding object more or less heated. The first steps to overcome this evil and its great expenditure of fuel were taken by Dr. Desaguliers, who encased the spherical boiler in brick work, a substance which he says was a "good non-conductor of heat and calculated to withstand the destructive action of the fire." He formed a furnace under the boiler with bars of iron to hold the fuel and a pit to receive the ashes. Round about the boiler he formed a flue leading to a stack through which smoke and other products of combustion passed.

At that period the rating of power of boilers seems to have troubled engineers and manufacturers. A boiler horsepower was rated as six gallons of water an hour evaporated at a pressure of one atmosphere, or fifteen pounds upon each square inch. One pound

[1]Plant Inspector, Pacific Gas and Electric Company.

of coal was capable of evaporating 6.14 pounds of water.

Boiler designs improved greatly from that time on, and patents were numerous. The external appearance of the boiler was greatly changed. The ancient spherical was replaced by the cylindrical or rectangular tank or by combinations of both.

Newcom, Watt and Bottom were the first to stay the flat surfaces of their wagon-shaped boilers. Smeaton in 1750 is credited with being the first to introduce an internal flue; Trevithic, the first to break up the water space by the introduction of tubes. Oliver Evans of Philadelphia was the first to introduce high-pressure, cylindrical, external-fired boilers, and he was also the inventor in 1786 of the first high-pressure engine. The history of Evans consists almost entirely of the romance of real life. Sanguine and energetic, he continually encountered difficulties and overcame them, and encountered renewed disaster and disappointment till at length he died of a broken heart.

Even at that early date engineers seem to have had their troubles. The Commission of the Franklin Institute of America was appointed to report on the structure, phenomena, and explosions of steam boilers. That commission consisted of Professor Walter R. Johnson, Benjamin Reeves, and Professor A. Dallas Bache. They framed the fundamental rules for boiler construction. Here is an extract:

"Standard strength of boiler-plate 55,000 pounds, strength after riveting 2/3, strength after heating and cooling in use 2/3, strain of permanent extension 2/5, greatest practical strength $=2/3$ of $(2/3-2/5)=1/6$ (nearly) of the actual cohesion, and the greatest practical strength to prevent explosion, being four times more than any boiler should be ordinarily worked at, we have 2/45 or 1/22 of the standard strength of the boiler iron, as its ordinary working pressure; 2500 pounds of extension on each square inch of cohesion action may, therefore, be assigned as the safe working strain of iron boilers."

About this time the marine engineer first made his appearance. To him we are greatly indebted for the very great efficiency of the Scotch marine boiler as regards both performance and workmanship. At first ship owners were so pleased at having their ships making regular trips between ports, independent of the elements, that the great space occupied by the engines, boilers, and coal was for a long time not considered. But, with the desire to increase the steamship's earning capacity, the boiler went through many changes, from rectangular wet-bottom to rectangular dry-bottom, from combinations of rectangular and cylindrical to cylindrical with the introduction of water--tubes and smoke-tubes. Witherhed, an American, was the first to introduce superheated steam. But engine design had not progressed as rapidly as or even kept pace with boiler improvements, so super-heating had to be abandoned, as the steam raised to a high temperature was found to damage the valves and pistons of the engines and to burn the hemp packing.

It was not until 1859 that the Peninsula and Oriental steamship "Alhambra," plying between Southampton and Lisbon, was fitted up with Lamb and Summers super-heaters. The temperature of the steam as heated was only 360 degrees Fahrenheit, and the super-heater surface was four square feet the nominal horsepower. The report claimed a saving of 37 per cent of the coal consumption with super-heaters, but this saving was due to the extension of the heating surface.

Engine design had all along retarded the development of the boiler. But with the introduction of the compound-engine pressures jumped from fifteen pounds the square inch to one hundred pounds the square inch. With the further development of the triple and quadruple-expansion engine pressures have risen to two hundred and ten pounds the square inch and small boilers have been made to do the work of large ones. Forced drafts were introduced, first in a closed stokehold as introduced in the navy, then through closed ashpits as planned by James Howden, and lastly by induced draft in the stack as introduced by Ellis and Eaves.

In conclusion let us turn to the development of the water-tube boiler, which is now the boiler generally adopted for all purposes in generating steam. The Pacific Gas & Electric Company is so cosmopolitan in its ideas that it uses the following boilers: the Roberts, the Heine, the Babcock and Wilcox, the Stirling and the Parker. The first water-tube boiler recorded was made by William Blakeley in 1766. But the first successful user of the water-tube boiler was James Ramsay, an American, who, in 1788, patented a water-tube boiler for use in steam navigation. Here may be mentioned some of the earlier inventors such as Wolf, Stevens, Griffith, Eve, Belleville, Wilcox, Clark, Moore. Special mention should be made of Julian Belleville as a most persistent and prolific inventor. He commenced work on the boiler question in 1850, and for a time was comparatively successful. But in 1900 his boiler was finally condemned for use in the British navy by a royal commission.

Sir Albert J. Durstan, engineer-in-chief of the British navy, is to be highly commended for the stubborn stand he made, in spite of the opposition he met from the engineers of all countries, when, in 1894, he installed the Belleville boilers in the British men-of-was "Terrible" and "Powerful." There were forty-eight boilers in each of these warships, with twin engines developing 25,000 indicated horsepower. The writer did considerable work on the "Terrible," in translating and redrawing from the French metric to the British standards.

The patent records show that every maritime nation is credited with a patent water-tube boiler. Even the Japanese, the most progressive nation, use their own patent water-tube boiler in their navy. The principal types are the inclined-tube, like the Babcock and Wilcox; the bent-tube, like the Stirling; the water-leg, like the Heine; and the latest, the down-flow-type, patented by J. C. Parker. The Parker boiler is comparatively new, and has been very much criticized both favorably and unfavorably by many eminent engineers. But the fact that it is gaining headway and becoming a factor in the market proves that it has merit.

I would refrain from expressing an opinion on any boiler in case of controversy, but suffice it to say that the best kettle is the one that will stand up to its work and require the least amount of expense in maintenance.

THE PROGRESS IN OIL GAS MANUFACTURE.[1]

BY J. M. BERKLEY.

The progress and development of any commercial undertaking can be best measured by the results it shows on the balance side of the ledger, for commercially speaking, the balance side is the "watch dog" of the treasury.

To supply the need of the great Coast country—it being without coal, the mother of development in due time laid her hand upon her natural resources with the result that crude oil gas was born to do the will of man and furnish the comforts and advantages equal to other parts of our country favored with great mountains of coal. The name is quite as descriptive as that of coal gas for the same reason that it possesses within itself all that is required for production.

Great progress has been made in this new gas which is only a few years old. Its adaptability is evidenced by the almost general use on the Pacific Coast. California alone, according to Brown's 1910 Directory, shows sixty-five operating companies all delivering crude oil gas except one which is coal gas.

Many forms, or types, of apparatus are in use each with many claims to support their superiority. Some are almost freaks, being products of amateur minds and their operation only made possible by reason of the ease with which this particular kind of gas can be made. It is now coming to be generally understood that it requires more than merely heating the brick hot, on which oil is poured, splashed, or sprinkled to make a commercial success of the undertaking.

Coal gas has been in process of development more than one hundred years and long since reduced to well known scientific lines. The same is due to the large corps of engineers whose names have become monuments in industrial history, both past and present; and, as time goes on there will be added to the already illustrious list, of crude oil gas engineers, the names of others who by hard work and close application are lending hands that will make greater progress possible in the future and bring credit to the industry.

Water gas has also seen its day of fad and fancies until now it is a marvel of success.

Much remains to be done in the further development of oil gas as is evidenced by every day's facts around us. Oil itself will be responsible for much new work, for as time and demands make inroads on the supply, new conditions will present themselves, such as lower gravity, higher sulphur content, as well as the new uses for the products of refined oil made possible by improved methods of refining. Each will have a great influence on both cost of production and require new investment in apparatus to meet these on-coming conditions. We must not overlook these matters, especially in view of the agitation of the rate regulation now going on so vigorously and which is liable to become general, at least in California.

After crude oil gas is generated and passes the first washer, it is treated much the same as other gases; therefore, the real battle ground for development has been in forms and types of generators and washers, and there has been and is yet quite a difference of opinions as to which type is best. In a recent visit to fifteen towns—outside of Los Angeles—ranging in population from 35,000 to 3500, thirty-four generating sets were found showing ten different types of generators in use. It is quite difficult to check their operation for in most cases they do not have station meters, the absence of which is also very noticeable even in some of the larger companies in California. Without the use of station meters to measure the output, it is as obviously wrong to set an array of figures to prove an operating cost as it would be for a merchant to tell just where he was at without the use of scales and yardsticks.

Oil from different fields will not yield the same amount of gas per gallon any more than coal from various fields will yield the same amount of gas per pound; therefore, it is wrong to expect uniform results even from the same type of apparatus under variable conditions. A classification of both oils and apparatus is greatly needed in order that we may get incontrovertible figures, then comparisons can be made that will compare.

The difference of opinions heretofore claimed for generator sets, composed of one or two shells, is evidently settling itself in favor of the one shell type as possessing all the functions required in the complete manufacture of crude oil gas. It was once thought that the whole operation could not be made complete in one shell nor would it be possible to get an arch that would stand the ravages of blasting and support the checker brick. The result is that there are in daily operation many such sets from four to twenty feet in diameter doing daily duty and that for several years past ,which is quite sufficient evidence. Such machines operate faster, cast less to build, less to maintain, with checker brick often lasting from twenty-four to thirty-six months, are easily kept free from carbon and naturally cost less to operate.

With the introduction of electric byrometers, used for obtaining internal temperatures, further advancement is assured with the result that speculation now finds no part in the heat required in generators; it can be easily ascertained and fixed to suit different kinds of oil. Using oil known as Whittier we have found the best results by maintaining an average of 1750 degrees in the vaporizing chamber, or space above checker brick, with a gradual increase down to the furnace where it reaches about 2200 degrees. With a change of oil to the Olinda field, we found we could lower our heats from 50 to 100 degrees on account of the oil fracturing at a lower temperature, thereby saving fuel oil.

Another important feature has been developed in oil scrubbing and has been brought to its high state of perfection by the company represented by our president. The efficient work of preventing naphthalene from getting into the mains is evidenced by a comparatively small percentage of complaints from that cause. It will well repay the time required to investigate the advantages.

In the matter of washers the best type is the simplest, that is, one producing even submergence and quick release with good facilities for cleaning.

The operator should not be overlooked as he is the most valuable asset in efficient operation. He should be educated so that he is a skilled workman

[1]Paper read at eighteenth annual convention Pacific Coast Gas Association, September, 1910.

and should know why he performs his duties. Intelligence is always superior to machinery.

Great possibilities no doubt lay ahead of us in the future use of lamp-black—the average gas man's nightmare. The manufacture of lamp-black into briquettes for fuel purposes is developing into quite an industry. In the manufacture of water gas it is finding a large use which will increase in the proportion of lamp-black productions.

It is quite evident that the time is not far distant when our present cherished ideas will be replaced by new requirements and the present methods will be the means of bringing to us better things. To the young men who are coming on with great opportunities before them, belong the privileges of bettering the pioneer work done by those who have passed and are passing and who have stood the brunt of battle and heat of day. The opportunities are sufficient to stir any one to the closest application for surely laurels of victory await the victor.

CRUDE OIL SMELTING.

The Washington Steel & Iron Company, Spokane, Wash., has commenced the construction of a plant at Leavenworth, Wash., 25 miles west of Wenatchee, to work the Rothert process for making high-grade tool steel from titaniferous magnetic ore by one operation. Exhaustive tests are said to have been made of the process in the experimental plant of the company at Hoquiam, which will be removed to Leavenworth. Crude oil will be used for fuel in the company's own specially constructed furnaces. A large mill site has been secured at Leavenworth which is ideal for the handling of the ore and the operation of a plant of large capacity. It will be but 15 miles from the ore beds and immediately on the railroad. It is stated that the company has near Blewett a deposit of 20,000,000 tons of iron ore. Associated with the company are M. A. Comer, of Wallace, Idaho, and J. L. Torkedson, O. P. Moore and E. K. K. Allen of Spokane. E. H. Rothbert is general manager.

CIVIL SERVICE EXAMINATIONS.

Examination for inspector of mechanical and electrical engineering is announced by the United States Civil Service Commission on December 7, 8, 9, 1910, to fill a vacancy in the position of inspector of mechanical and electrical engineering in the Supervising Architect's Office, at $2190 per annum, and vacancies requiring similar qualifications as they may occur in any branch of the service. The duties of the position consist of inspecting and testing the mechanical and electrical equipments entering into the modern Government or office building.

Examination for fortification draftsman is announced by the United States Civil Service Commission on December 7-8, 1910, to fill vacancies as they may occur. The usual entrance salary for this position is $1500 per annum.

Examination for cartographic draftsman is announced by the United States Civil Service Commission on December 7-8, 1910, to fill a vacancy at $3.84 per diem, Naval War College, Newport, R. I.

DISCUSSION OF PAPERS AT EIGHTEENTH ANNUAL CONVENTION PACIFIC COAST GAS ASSOCIATION.

"Progress in Oil Gas Manufacture."

President: Gentlemen, we have heard a very excellent paper. I would like to ask Mr. Egner, who has been traveling around the Pacific Coast during the past few months, and visited a good many plants, what has impressed him the most in the way of oil gas manufacture.

Mr. Egner: Mr. President, gentlemen of the Association; I came here to learn and not to talk. I came a very long ways. I listened to Mr. Berkley's paper and was very much interested in it. I can also say I have visited his works. I have visited a number of works, and I hope nobody will take exception when I say that I have not seen one so ship-shape, so well designed, so well kept, as the works over which Mr. Berkley presides.

Now as to oil gas, I was somewhat acquainted, about 18 years ago, in the old State of Illinois, with a process called the "Kendall process," something like what you have here today. It was about the first I ever saw, but you have made great improvements. I did not think it was possible to get the results that I find you are getting by making gas with the miserable stuff you call oil—the oil you are getting. If I had known I was going to be called on to speak I would have had a few more figures about this, but you all know so much more about oil gas than I do, that I know you will excuse me.

President: I would like to ask Mr. Jones what he considers the greatest improvements in the matter of oil gas manufacture in the last few years.

E. C. Jones: That would be very difficult to answer.

President: In your opinion.

E. C. Jones: I have listened to Mr. Berkley's paper with a great deal of interest. It deals with many generalities. The facts stated do not seem to call for an answer, but having been brought up with the old gas business from its inception, it having been forced upon me in the absence of other gas material, I feel it would not be right for me to remain in my chair without saying something. What Mr. Berkley says in regard to the absence of station meters in California is true. Unfortunately it is true. Mr. Berkley, of course, as an engineer, knows whether a gas meter is merely a guessing machine, depends on its accuracy by a test of a meter prover or small gas holder. If you measure gas with two large meter provers, and keep careful account of the changes of temperatures, you have a meter that cannot be approached by any other mechanical device. It bears the same relation to the measuring of gas as a gallon bears to the measuring of liquids. If you determine it contains 231 cubic inches, you feel satisfied that it is true. This is the means of measuring gas in many large gas works in California.

The next thing is in relation to the one-shell machine, which we call, in Southern California, the "straight-shot." I am opposed to it because I do not believe all the functions of gas manufacture can be performed in any one-shell machine. It has been tried for many years. I tried it in many ways and found that if the heat is applied to either the top or bottom of a one-shell machine, that there is a great deal of heat which cannot be used for gas making, and if heat is produced it costs money, and it should be used for the distillation of oil. Otherwise it is wasted. This, I claim, can only be done by an apparatus consisting of two or more shells—and gentlemen, let me say, there is not a bit of commercialism in my remarks. We are both gas men talking over without fear or favor what we believe. Some people tell us we should burn the oil in the bottom of a "straight shot" or single cylinder shell. If we do so we allow the top to become hotter than the bottom, and it becomes necessary for the gas in the bottom and middle to be taken out at the top, with a result that the gas itself is decomposed, with the result that we have lamp-black.

In the development of oil gas processes, it was found that what at that time was thought to be one of the hottest gases, viz: hydrogen, existed in large quantities; now, hydrogen, in the old days of coal gas, was considered very desirable because

it burned with a great deal of heat. This is true where we measure hydrogen by the pound, as it is very light, but when we measure it by volume it immediately drops to the value of carbonic oxide. There is one difference between hydrogen and carbonic oxide. Hydrogen is a false diluent. It reduces the specific gravity of gas and it compels the consumer to be very watchful or he will use much more gas than necessary. Now we find it is undesirable to have too much hydrogen in our gas; how shall we remedy it? By having a greater number of shells than one, conserving our heat, getting the heat equally distributed, and when the gas is finished taking it out of the oven the same as a loaf of bread. If you have an incubus of heat it must be used for some purpose, and the oil has to go through that in order to make gas, but don't compel gas to go through the hot zone and be destroyed.

In dealing with pyrometers, I find the Mr. Berkley is correct and incorrect. The pyrometer which is manufactured in this country and Europe is extremely valuable purely as an experimental instrument, but not to be relied upon in constant use. I have seen generators provided with electric pyrometers which registered a low temperature; at the same time there was being produced a good deal of naphthalene; the heat was not indicated by the pyrometer because the pyrometer was not in the right place.

The matter of oil washing follows naturally on the recommendation to use single shell machines. We all know that the use of oil for washing gas is not a good thing. The relationship between the hydro-carbons of which our gas is made—the elements that constitute our gas—is so great that there is a sort of cousinship existing between all these hydro-carbons and when you take finished gas and wash it with oil all the cream of the gas gives itself to the oil. It is best to keep this cream in the gas even though it contains a certain amount of naphthalene.

I would like to tell you what we are doing in cities outside of San Francisco, but it would take up too much of your time to do so. I am simply considering the generalities dealt with by Mr. Berkley. If you see a "single shot" or straight or single shell machine, and you get a good deal of naphthalene, you must of course use oil in scrubbing it out—scrubbing out the naphthalene, and candle-power at the same time.

President: Mr. Latta, the convention would like to hear from you.

Mr. Latta: I want to say that I am so much interested in my visit to your coast that I am still in a condition of flux, and I have not been able to definitely formulate an opinion on the matter, and data which has come before me. In a general way, it is a great surprise to me that you are able to make gas in single shell machines. One reason is that the experience of water gas operators has practically conclusively shown that oil must be broken up at one temperature, and fixed at another and the fixing temperature is lower than the temperature at which they are broken up. Any tendency to reverse that operation invariably "cracks" the gas which has been made, and causes the production of the carbon.

I have had occasion to examine some experimental work which was being carried on by a very large company in this country for the manufacture of producer oil gas, the effort being to manufacture and produce gas by gradual dissolution within single shell, and this is the condition of affairs created: Their idea is to enter the oil at the top of the shell and break off each fraction of the oil as it goes down, increasing the heat and taking off the gases and lighter fractions without destroying the more delicate hydro-carbons. The result has been very satisfactory with the exception that a good many of the hydro-carbons are not properly fixed. This is because the time of contact has been too short, and the new elements have not had time to become permanently fixed. An attempt has been made to fix those by passing it down through the lower heat center, which practically made a single shell operation, and the result was more lamp-black, so it was given up as a commercial loss.

I am suggesting these facts merely theoretically. I may have no definite knowledge of the operation of your oil machines, but I am very much surprised and very much interested that you have been able to overcome these objections which seemed, from a physical standpoint, insurmountable.

President: I understand that Mr. Wade has some interesting data on the subject.

Mr. Wade: This is some very interesting data the speaker gave us, but the matter of the oil passing at the highest temperature is abolished under the single shell machine. The oil is actually spread and put in on the checker brick. The lower part of the machine is where the gas is taken off. The oil is spread in at the top and the gas taken off at the bottom. The lower part of the machine is the coldest part. The oil as injected burns in a flame something on the style of the Bunsen burner system, which is coldest at its lowest part. I think that is the way those results are accomplished. This question of fixing gas, I think, is more involved—considered more involved, much more, than it is. I do not just understand what the "fixing," as the gentleman stated, is. My idea of the thing is that as soon as the oil is decomposed it is fixed.

I agree with Mr. Jones that there is some solution of all valuable parts from the gas when it passes through oil, but I think that solution is made up by carbide, enriching the gas. There are hydro-carbons that are carried away, enriching the gas, so that anything that is dissolved is made up by hydro-carbons that are dissolved by the oil and taken out. That is the only way I can account for the fact that gas enters our scrubber at 601 units and is taken out at the same.

Mr. Britton: I would like to ask Mr. Wade, in this case—if that is the case—what is the good of the scrubber?

Mr. Wade: It removes naphthalene, which is solid hydro-carbon.

Mr. Britton: Naphthalene is the best illuminant you carry in your gas.

Mr. Wade: It is extremely difficult to distribute.

L. P. Lowe: What gravity oil do you use in the washer?

Mr. Wade: 20.

L. P. Lowe: That will volatilize at 150 degrees?

Mr. Wade: Its flash point is about 90.

L. P. Lowe: At what temperature would you put the gas into the oil?

Mr. Wade: 85 to 90.

L. P. Lowe: Under those circumstances you assume that you get volatilization of your lighter oils sufficient to overcome the loss due to absorption of naphthalene and other vapor?

Mr. Wade: The actual loss of candle-power is naphthalene is so extremely small in oil with a flash point of 85 to 90 degrees—it is so small that I do not think it can have any effect. I do not see how it can have any effect.

L. P. Lowe: Take gas of say 20 candle-power, carrying possibly six-tenths of one per cent hydro-carbon vapors, and remove them and what effect on the candle-power would their removal have?

Mr. Wade: Probably 25 per cent. That six-tenths of one per cent is extremely important..

L. P. Lowe: I think you take out very much more. I recollect a little uncomfortable experience I had before this association a number of years ago when I presented a paper entitled, "The Synthesis of Illuminating Gas." I prepared the seven principal gaseous constituents in bottles and showed and burned each one separately. In order to show all of the seven constituents, it was necessary to prepare ethylene, as the nearest approach to the so-called illuminants, and when I mixed this with the non-luminous gases in presumably the proper proportion, I was surprised to find I had only a practically non-luminous flame. I thought I could "steal a sneak" on the association, and quietly passed in about seven or eight times as much ethylene as there should have been, and was more greatly surprised to find it did not bring up the candle-power very much, and right there I learned a valuable lesson, which is that the illuminating power of our ordinary gases is largely due to the benzine and other hydro-carbon vapors contained therein.

Mr. Wade said a little while ago that he didn't know what "fixed" gas meant.

Mr. Wade: Of course I know what it means in this case—a gas that can be distributed at its original candle-power.

L. P. Lowe: A fixed gas is simply a gas that has no vaporous contents; once a gas, always a gas, and if you think you can permanently change it through physical means, you are much mistaken. You can simply so change the vapors, which never were gas. A fixed gas is a gas which will not alter its physical condition under ordinary conditions, but the vapors in that gas may deposit, and are deposited, with physical changes. If you can hold the naphthalene vapors in suspension you are retaining one of the most valuable constituents of your gas, and I believe it is possible to do so by simply removing a small portion of the water vapor, which is almost always present, after which the hydro-carbon vapors will remain in suspension.

Van E. Britton: From a commercial standpoint, is it worth while?

L. P. Lowe: Yes.

E. C. Jones: In discussing the relative merits of washing with oil or water, I had in mind a point where I am at present washing with oil, and it is compulsory—the conditions are such that we must wash with oil. It is compressed gas—under high pressure—and there is a difference of about two candle-power between the inlet and outlet of the oil washer. The loss in candle-power is approximately two candle-power. Now, I would like to say to Mr. Britton that we will suppose there is a municipal ordinance that requires 19 candle-power for merchantable gas. We will suppose that the municipality requires 19 candle-power. You have gone through the process of making your gas, using the standard amount of oil per thousand feet, and you find you have a candle-power amounting to 19. You put it through the scrubber and you have 17 candle-power. How can you comply with the requirements?

Mr. Wade: I wish to say one or two more things on this ethylene process. I think a good deal of it because it has certainly proved successful with the Los Angeles Gas and Electric Corporation. I took the trouble to get these details on naphthalene. This work was done by the University of Michigan in the Gas Fellowship, supported by the Michigan Gas Association. The amount of naphthalene which any gas or amount of vapor which any volume of gas can carry is measured by the temperature. Here I have the amount of naphthalene which can be carried by 100 cubic feet of gas at 70 degrees, which is 24 grains—that is the limit. I find 120 corresponds to .6 per cubic foot of gas. Six-tenths of one thermal unit can have no real effect on the heating or lighting value of the gas. Personally I think the heat value is the standard for modern gas purity. The Wisconsin Public Utilities Commission has adopted a single standard, and that, I think, is the tendency of all public utility commissions now. At the Los Angeles Gas & Electric Corporation, we are putting in gas of say 630 British thermal units, and taking out gas within practically one or two British thermal units.

L. P. Lowe: I think possibly there is something misleading in that statement, relative to the amount of naphthalene vapor which can be carried in the gas without depositing at certain temperatures. It depends on the presence of other vapors, does it not?

Mr. Wade: In the experiments carried on at the University of Michigan, they treated water vapor and benzol vapor, and there was absolutely no difference in the presence of water vapors, and but a slight increase in the benzol.

L. P. Lowe: Am I to understand that the gas was surcharged with water vapor?

Mr. Wade: Yes, sir.

L. P. Lowe: And that after removing the water vapor then, at 70 degrees Fahrenheit, would carry only 24 grains naphthalene per one hundred cubic feet of gas?

Mr. Wade: Yes, but it is a rapidly rising scale. The increase is very sharp. Let me give you one or two figures. At 70 degrees Fahrenheit 100 cubic feet of gas will carry 24 grains of naphthalene. At 80 degrees 100 cubic feet will carry 42 grains of naphthalene; that is a raise of 8 degrees. At 90 degrees 100 cubic feet will carry 71 grains. It goes up very sharp. The difference between 80 and 90 degrees is very big, and for that reason troubles increase very rapidly above 80 degrees.

L. P. Lowe: Have you any practical results of operation? Can you briefly describe your method of oil washing?

Mr. Wade: The scrubber is an ordinary 20 foot in diameter by 60 foot high power scrubber, with 2 by 4 timbers used as a spreading medium, laid at intervals of two feet—two feet apart, with about three or four inches between and they are circular and go up so as to make a complete revolution. The gas comes out at the bottom.

L. P. Lowe: Do you re-circulate the oil? Does the gas come in contact more than once? Is it a circulating system?

Mr. Wade: It is both. The suction from the bottom—the oil circulates from the bottom and takes new oil at the same time.

L. P. Lowe: Have you analyzed the oil to determine the naphthalene?

Mr. Wade: Yes, but I never could determine it exactly. It is very hard to determine on account of the vapor.

Mr. Britton: What is the temperature of the oil?

Mr. Wade: Practically the same temperature of the gas. In the summer 85 to 90, and in the winter 70.

Mr. Britton: Do you utilize that oil after it has been used for scrubbing?

Mr. Wade: Yes, we use it for gas making.

Mr. Lowe: I have heard a great deal of the various merits of various types of oil gas making machines but after all is said and done, the real point is the amount of oil used per thousand cubic feet, provided the gas is of proper quality. Now, if Mr. Berkley has no objection to stating his results of manufacture, I am sure it would be of interest and if he does not wish it recorded the reporter can elimiate it.

Mr. Berkley: I believe I will make a general answer to all of the questions that have been raised while I am at it, and at the same time answer Mr. Lowe's inquiry.

With reference to the objection that was raised this morning on station meters, I take issue with the statement that a station meter is not a necessary adjunct to the gas works, and that accuracy can be obtained by measurement of gas through the relief holder. If such be the case, it must necessarily be that two relief holders are in continual operation—no gas admitted to the holder while reading is being taken. Therefore, there must be one filling while the other is being emptied, and if there is only one relief holder I know of no means whereby any man has been able to mathematically calculate the amount of gas going into the relief holder and the gas going out, and give an intelligent answer. If this can be done, I will be perfectly willing to stand correction. If station meters are not a necessity, then it must also be admitted that every well regulated gas works in the United States has something it does not need. On the other hand, it is quite impossible to tell the difference between your gas made and gas sold without a station meter, and the discrepancy between consumers' meters and the station meter cannot be established either as leakage or defective meters. The reading of a relief holder calls into account human intelligence and accuracy which too often is unreliable. The man reading the scale board with graduations of 1000 feet or less will not at the end of the day be able to give a correct sum of his work, as would be the case by a well regulated mechanical device, such as station meters are today. If you do not care anything about the leakage question, then the station meter could be dispensed with, and your oil consumption per thousand feet of gas can only be calculated on the amount of gas you sell. Then the question would arise as to the accuracy of the consumers meters.

Now, as to the single shell generator, and why we advocate it.

Over four years ago, when I came to the Pacific Coast, I was employed by the Edison Electric Company. I went to Redlands to do some repair work. I found there two good types of machines, known as the Lowe type. After awhile I was enabled to travel over their entire system; I found several different makes of generators from one to two shells. At Riverside I found

a single shell generator, made some years before, in operation and having what was considered a super-heater in the top or upper half of it. I converted it into a "straight shot" machine by taking the arch out of it. It worked admirably and, I am told, is still working. Our machines in Los Angeles are built along the same line as that found at Riverside, and are the result of observations made while studying these different types. I learned at the same time the Los Angeles Gas Company was using single shell machines, and making a great success.

The question was raised that a single shell machine would not, or did not, or was not competent to make gas at one and the same operation. I am confident—so much so that I am willing to assert, without being a chemist, that oil gas is made instantly; for as quick as the oil meets the checker brick, which has been raised to a sufficient heat, the immediate result is the fixed gas—not condensible except for that portion which condenses into lamp-black and any other portion where not enough heat has been exerted on the oil. I also believe that the quicker you can get the gas away from the point of contact with heat after perfect distillation, the sooner you will solve the question of successful operation. I believe that the longer the gas is kept in contact with the checker brick, or heated surface, or extended over any further heated period, it is robbed of its high hydro-carbon, and thus made poorer, which proof establishes the fact that prolongation within heated enclosures does not add to its value.

The question of first cost is answered in that it is one-half of what it costs to build any two shell type. The cost of maintenance is less; checker brick lasts longer in single shell generators than it does in double shell generators for the reason that there is less stoppage. In the double shell stoppage often occurs in the super-heater, or auxiliary, and necessarily creates a heavy back pressure on the generator itself, also the residue from the incoming oil created during the period of blasting, causes stoppage by reason of the fact it cannot escape and thus the heat burns down the checker brick. We have had two shell generators go down in three months for the above reason. Of the single shell generators, which we are now operating, we have some that are on their thirty-second month, and have been on continuous daily operation and under the most severe tests when you consider that our machines go up and down twice every day, that is, during the period of making and cessation as they are in operation only about one-half the time. Therefore, the brick are subject to the most severe hardship that is possible, and I believe it is even a greater strain than continuous operation. It is also true that we get twice as much gas per man employed on the generators as we would in operating a double shell type, for it requires two men to handle two double shell machines, where it only requires one man to handle two single shell machines. There are no valves in between any of our apparatus, as we depend on hydraulics to take care of each shell, thus making each one independent of the other.

We also find that the statement of varying heat in single shell generators, and the same being incontrovertible; such is not the case, as our experience shows. We put our oil in at the top of the generator, where the heat is much less than at the bottom. Our average heat is about 1750 degrees Fahrenheit in the vaporizing chamber. As the gas descends, when finding its way out, it reaches a higher temperature or about 2200 to 2300; and, our observations are that during the run we do not lose any of the oil injected above for the reason that there is a sufficient amount of heat in the top of the generator to vaporize any oil that is going down with the gas near the end of the run. Therefore, as I have said, I believe the gas is made instantly and if removed at that point is just as much a fixed gas as if you run it through a mile of pre-heated storage. The cost of operation is greatly lessened.

L. P. Lowe: What is the gravity of the oil you use?

Mr. Berkley: Twenty.

L. P. Lowe: Whittier oil?

Mr. Berkley: Olinda, now. Our average heat units for the year 1909 was 608, and I think it is about the same now. The city gas inspector's tests are close alongside of those that we made, showing no particular difference between the two.

Now as to scrubbers. I want you to know, gentlemen, that I am not taking exceptions to any remarks made during the morning with any but the kindest of feelings. I am not here to argue from a personal standpoint—I have nothing to gain or lose. Like my friend Jones, I own no patents; I do not know what happens in the oil scrubbers, but I do know what happens in our complaint department. I know when we run our oil scrubbers continuously our complaints go down. The total number of complaints we have compared with the total number of consumers for the first six months of this year, and the average is 2.8 per cent. If we did not have oil scrubbers, I know it would be many times that. We do not use oil scrubbers in some of our outside districts, and we have as many as one-fifth of our consumers complaining at times. I am a firm believer in oil scrubbers. The technical side I am not here to discuss, but the practical side I stand for, and if we are robbing the gas by our method of scrubbing, unless I am very much mistaken, we are recovering it again because we pump the oil right back into the storage tanks, and it goes through again; and, therefore, if we are absorbing anything from the gas by way of valuable illuminants, we must be recovering them through distillation. We are not holding to the theory that we are making gas cheaper today than anybody else, or better, or that we have the latest apparatus. I believe, however, as I have said in my paper, that it is not far distant when the systems we now have will give way to better ones, and I am willing to take off my hat to the man who hurries them along.

L. P. Lowe: How many thousand feet of gas will you make per thousand fire brick?

Mr. Berkley: Well, that I do not know. In our generators there are ten thousand fire brick in each of them, that is, outside of the triple arches. Our arches are very strong, the radius being two and three-quarter feet. It requires several hundred brick to build the arches and to bring the top to the flat surface where we begin our checker brick. I have calculations on the number of fire brick and cubic area, but I did not bring the figures with me. I will be glad to furnish you the information based on thirty-two months of operation.

L. P. Lowe: Well, per thousand of brick.

Mr. Berkley: I can tell you another way to get at it; we have made 600,000,000 cubic feet of gas in the two generators in which there are 20,000 fire brick, and they are still in use and are in good condition. How much longer they will last I do not know.

Mr. Britton: What brick do you use?

Mr. Berkley: We use Los Angeles fire brick of the same class as used by other companies. I am glad you asked that question. This brings to my mind the question of pyrometers, which were referred to this morning in the discussion by Mr. Jones. I want to add that I am a firm believer in, and advocate pyrometers. I know of no other method that is equally as good and until I find something better, I certainly will remain of that opinion. There isn't any method that will give us, by observations, as close readings as pyrometers. We have our instrument fitted wtih four switches, and we take off simultaneous readings at two different points on two generators operating together. This enables us to keep close tab how each generator is working under the same blast and oil pressure.

I had an occasion recently to take a pyrometer test from a two shell generator set; I found that the heat in these separate shells varied greatly from one side or the other, and it is impossible to get the same even readings that we can from the single shells because of physical conditions. It is perfectly natural to expect easier operation from the single shell than from a double shell type. To prove this, while employed by the Edison Company, we disconnected a junior set of Lowe apparatus at Riverside, and took away the super-heater and putting the stack valve on top of the generator we made more gas with it. Of course, we put in new checker work and we were so much more successful than we were when connected together.

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The Circle Diagram

There are two mathematical means of explaining the theory of alternating currents, the analytical and the graphical, which have about the same mutual relations as algebra and geometry, or more specifically as calculus and trigonometry. Some men actually think in calculus, just as they might think in German or in the metric system without need of translating into English words or into English units. A mathematical equation gives to them a vivid mental image of what is taking place in a transformer or motor, the different symbols clearly representing the relations between variable or indeterminate quantities.

There are many others to whom these equations mean nothing but tedious mechanical operations, but to whom the graphical methods bring ready realization of what is taking place. The brain can be reached more quickly through the eye than through any other sense of human nature. "Seeing is believing." Lines, curves, angles and areas appeal directly to the sight and help to visualize the problem. As regards simplicity and clearness they are like the sign language by which savage and civilized man alike can make known their wants. The graphical method is of value not only in explaining complex matters to a beginner, but also in giving the adept a mental picture which materially aids him in his more exact analytical calculations. For the graphical method has not the extreme accuracy of the analytical, giving results which are only approximate, but usually near enough for practical work. Adopting the chemical parlance, the graphical method may be said to be qualitative, while the analytical method is quantitative. A simple diagram carries conviction where mathematical manipulation cause confusion.

The circle diagram is one of these graphic ways of explaining the action of induction machines. Since its original development by Heyland in 1894, it has been somewhat simplified through various modifications and is now well adapted to the beginner's use. It is based upon the assumption that an induction motor may be regarded as a transformer whose secondary furnishes mechanical instead of electrical energy and which also has a large magnetic leakage. In plotting the current and voltage vectors of an induction machine under different loads it is found that the end of the vector, representing the primary current, moves in the arc of a circle as the load changes. Hence the name "circle diagram," the circle representing the locus of the current.

Aside from giving an optical illustration of the action of the induction motor and generator, the circle diagram is also one of the simplest means of obtaining the characteristic curves of these machines, showing the speed, torque, power factor and efficiency at various loads. While this method does not give absolutely accurate results, errors are so small that for all practical purposes they may be neglected, especially as they often tend to cancel each other. The diagram is laid out to scale and from it all the desired data can be measured. How this is done and why is admirably explained in F. G. Baum's paper on the "Induction Motor and Generator" as published elsewhere in this issue.

CURRENT COMMENT

The poorest heat conductors, aside from infusorial earth, are wood ashes and cement.

Telephoning from New York to Denver, a distance of 2200 miles, will be possible in 1911. The two cities will be connected by phantom loaded overhead circuits.

Calcium cyanamide, hitherto used chiefly as a fertilizer, is now being used as a substitute for potassium cyanide in the Clancy process of extracting gold and silver from unroasted sulphide ores by electrolysis.

The h.p. hour weight of a lead storage battery varies from 60 to 80 lb. while that of an equivalent compressed air storage system is over 200 lb. The Edison battery has even less weight but occupies greater space.

The cost of one c.p. hour has been estimated by a German authority to be equal to $w\,f + a / (s\,n)$, when w is the watts per candle-power, f the cost of a watt-hour in cents, a the cost of the lamp in cents, s the useful life of the lamp in hours and n the candle-power of the lamp.

Oil pipe lines from Coalinga include two belonging to the Standard Oil Company going to Richmond by way of Mendota; one, belonging to the Associated Transportation Company, leading to Monterey bay; another that of the Associated Pipe Line Company, extending to Port Costa; and the fifth, the property of the Producers Transportation Company, connecting the Coalinga, McKittrick and Midway districts with Port Harford.

Copper castings of high electric conductivity, free from blow holes and of all sizes and shapes are now being made in foundries by adding a small amount of boron suboxide to the copper when melted. The casting can be easily machined, is much cheaper than forged copper and less bulky than any of the usual alloys. This "boronized" copper has recently been developed by Dr. E. Weintraub in the research laboratories of the General Electric Company.

Boiler corrosion may be prevented by the use of zinc and tin according to the following method suggested in a paper by Carl Hambuechen at the recent Chicago meeting of the American Electro-chemical Society. An iron rod coated with tin and supporting zinc rings is tightly bolted to the inside of the boiler shell, the zinc being replaced as corroded. The tin by its overvoltage effect is always kept clean and consequently insures the good electrical contact necessary.

Triboluminescence, or light arising from friction, is exhibited by certain zinc minerals and in artificial zinc compounds such as a mixture of seven parts of powdered zinc carbonate and three parts of sulphur mixed with distilled water containing a trace of manganese sulphate. This mixture is first gently dried, then powdered and finally heated to redness for twenty minutes in a covered crucible. When scratched with a sharp point a train of yellow sparks are emitted which will not ignite a gas or vapor as does the alloy of cerium and iron perfected by Welsbach.

California's copper production in 1909 totaled 65,727,736 lbs., valued at $8,478,142. Shasta county was the largest producer, with 58,665,477 lbs.

An emulsified cylinder oil has much less lubricating power and must consequently be used in much larger quantities than a clean oil. The emulsion is also easily washed from the cylinder walls, which further increases the consumption.

The Paris-Madrid telephone line, 900 miles long, is expected to be ready before the end of 1911. Paris is already telephoning to London across the English channel, and equipment is now being installed to handle 400 messages daily.

The Heroult patents for electric steel making and refining in this country have recently been acquired by the United States Steel Corporation who have been operating 15-ton Heroult furnaces at South Chicago, Ill., and Worcester, Mass., for some time.

The Stia electrolytic meter gives a direct reading of the number of ampere-hours much as temperature is read from a thermometer. Electrolytic action decomposes mercuric nitrate, liberating metallic mercury which drops into a tube graduated to give the number of ampere-hours.

A wireless telegraph directory has been published by the Bureau of Steam Engineering of the United States Navy. It lists all stations throughout the world, according to country, giving call letters, wave length, power, range and character of station. Exclusive of foreign ships and of amateur stations, there are 1520, 700 being shore stations. The U. S. Navy maintains 47 shore stations and 344 ship installations.

An excess power meter for recording the amount of electrical energy consumed above a certain prearranged amount was recently shown at an exhibition of the Physical Society in Paris. On the axle of an ordinary meter is mounted a concentric nickel cylinder revolving between the poles of permanent magnet. The meter cannot start registering until there is enough current to overcome the counter torque due to the energy consumed by the hysteresis in the nickel cylinder.

Electric cooking has been strongly recommended by a board of U. S. Navy officers who recently conducted a series of comparative tests of electric ranges and coal ranges. Meats and vegetables for from 100 to 150 men were better cooked in almost half the time by electricity, no matter whether fried, boiled, broiled or baked. Ten pounds of meat were roasted in one hour and forty minutes by 7 kw. hours, whereas it required two hours and twenty minutes for 41 lb. of coal to accomplish the same result. The final conclusion of the report was that the electric range should supersede the coal range on board ship because of its cleanliness, economy of time, space, and operating, and elimination of coal boxes, draft troubles, soot accumulation and excessive heat in the galley.

PERSONALS.

George F. Maddock of H. M. Byllesby & Co.'s Portland office, arrived at San Francisco last week.

T. A. Work, of the Monterey Gas & Electric Company of Monterey, Cal., visited San Francisco this week.

Thomas Mirk, of Hunt, Mirk & Co., returned to San Francisco last Monday from a trip to San Diego.

Chester H. Pennoyer, manager of the National Conduit & Cable Company, left last Monday on a tour of Southern California.

Walter S. Allen, an official of the American Bell Telephone Company, of New York, was a recent visitor to the Pacific Coast.

R. W. Van Norden is making an examination of water-power possibilities in Plumas county, California, for a foreign syndicate.

C. W. Waller, of the Mojave Water & Power Company of San Francisco, recently returned from a trip through the Pacific Northwest.

H. H. Noble, president of the Northern California Power Company, left for Redding last Wednesday on an inspection tour of the system.

H. L. Jackman, manager of the Humboldt Electric Light & Power Company, of Eureka, was a San Francisco visitor during the past week.

W. S. Heger, California manager for the Allis-Chalmers Company, returned to San Francisco last week after visiting his Los Angeles office.

S. N. Griffith of Fresno, who is constructing a new electric railroad in the San Joaquin Valley, spent a few days at San Francisco last week.

President J. A. Driffle and vice-president J. S. Torrance of the Ventura County Power Company, Ventura, Cal., have interchanged positions.

P. O. Crawford, electrical engineer with the Northern California Power Company, has returned to Redding after attending the varsity football game at Berkeley.

J. W. White, of the sales department of the Fort Wayne Electric Works, is making a business trip through the mining districts of Northern California and Southern Oregon.

Sidney Sprout returned last Tuesday from Oxnard, where he has been doing engineering work in connection with the electric plants of the Ventura Power Company's system.

Edward L. Haines, electrical engineer with J. G. White & Co., Alaska Commercial Building, San Francisco, has been appointed secretary of the San Francisco Section, A. I. E. E., for the ensuing year.

E. V. D. Johnson, general manager of the Northern California Power Company, who came to San Francisco last week for a slight operation following an automobile accident, is rapidly recovering at a local hospital.

J. Jenkinson, meter man with the British Columbia Railway, Light & Power Company of Vancouver, B. C., returned home this week after refereeing the Rugby football game between the universities of Stanford and California.

G. R. Field, assistant general manager of the Great Western Power Company, spent several days during the past week in the vicinity of the Big Bend of the Feather river, where a large plant is in continuous operation and improvements are being made.

C. E. Groesbeck, one of the vice-presidents of H. M. Byllesby & Co., of Chicago, spent the past week at San Francisco, conferring with representatives of his own and other corporations having extensive electric power interests on the Pacific Coast.

J. B. Adams, formerly in charge of the Pacific Gas & Electric Company's Colgate plant, has been made superintendent of the De Sabla Power Division, vice I. B. Adams, who has resigned to go to South America. The Colgate hydroelectric plant is now in charge of Joseph Mini, Jr.

Newly-elected associates of the A. I. I. E. include J. C. Albert, electrical inspector, Pacific Electric Railway Company, Los Angeles, Cal.; F. E. Alexander, electrical engineer, Anaconda Copper Mining Company, Butte, Mont.; E. J. Barry, electrical engineer, Potlatch Lumber Company, Potlatch, Idaho; R. R. Easter, operating department, Seattle-Tacoma Power Company, Seattle, Wash.; L. Edwards, shift operator, Vancouver Power Company, Ltd., Lake Buntzen Power House, Burrand, B. C.; R. W. Grigsby, consulting engineer, Los Angeles, Cal.; C. L. Hoon, electrician, Los Angeles aqueduct, Brown, Cal.; H. B. Lynch, manager lighting department, City of Glendale, Cal.; A. H. Noyes, electrician, Snow Mountain Water & Power Company, Ukiah, Cal.; J. Petersen, manager, Frank E. Harmon Co., Portland, Ore.; E. Popper, shift engineer in charge, United Missouri River Power Company, Butte, Montana; A. LeR. Taylor, laboratory assistant, University of Utah, Salt Lake City, Utah.

TRADE NOTES.

Standard Electric Construction Company has the contract for wiring the Pullman shops, at Point Richmond.

H. L. Harkness, Metropolis Bank Building, San Francisco, opened offices as manufacturing agents for contractors' supplies.

The Electrical Appliance Company of Portland has been absorbed by the Barretts Company, Inc., of 410 Morrison St., Portland, Oregon.

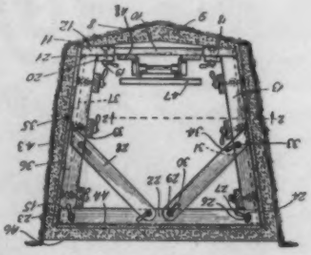
The Pacific Surety Company of San Francisco are adding a department for the insurance and inspection of fly wheels and boilers. C. M. Hausen, for the past two years manager of the Pacific Coast division, inspection department, of the Maryland Casualty Company, will take over the management of the inspection department of the Pacific Casualty Company, December 15.

The Pelton Water Wheel Company of San Francisco has sold to the Klamath Falls Light & Power Company a Pelton-Francis turbine water-wheel of 1050 h.p. which is to be direct connected to a Westinghouse generator operating at 400 r.p.m. The wheel will have a double cylindrical case and will operate under an effective head of 46 feet at the town of Klamath Falls. A Pelton oil pressure governor will he used in connection with a mechanically operated relief valve.

The Hydroelectric Company has purchased for its power plant on Mill Creek, near Bodie, an additional Allis-Chalmers 1500-kw. 2200-v generator. It will be direct connected to a 2500-h.p. Pelton impulse wheel which is to be operated under a head of 680 feet at 400 r.p.m. A Pelton automatic needle nozzle will be directly actuated by a Pelton oil pressure governor. The Fort Wayne Electric Works secured the contract for all of the switchboard equipment. The General Electric Company will supply all of the transformers. D. A. Chappell is president of this company which will start up its initial unit of 1500 kw. already installed, within a month or two. Current will be transmitted over the main transmission line at 55,000 volts. Two 600-kw. substations have been installed at Aurora and Bodie and extensions will be built to Fairview and Wonder, making about 75 miles of transmission line. The Bodie Consolidated has installed an electrically driven air compressor and will use Starrett pumps for mine drainage work.

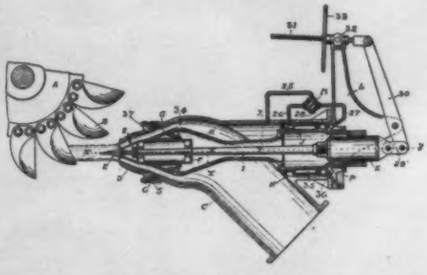
PATENTS

974,960. Apparatus for Making Conduits and Tunnels. John Phillip Grohs, Los Angeles, Cal. A form of the class described, comprising a frame having a bottom sill, rotatable blocks on the upper side of said sill near the ends thereof, posts stepped on the ends of said sill and abutting the outer



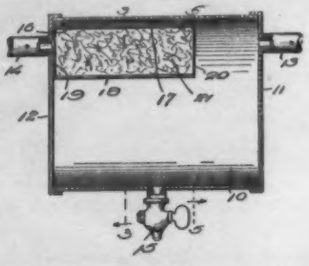
faces of said blocks, said posts diverging outwardly in an upper direction, the upper ends of said posts having seats formed thereupon, a beam resting on said seats, diagonal braces pivotally attached to said beam, means for detachably securing said diagonal braces to said posts, side-panels, and means for attaching the same to said posts.

975,350. Valve for Water-Nozzles. Frederick Gfeller, Oakland, Cal. The combination in a pressure discharge nozzle, of a convergent exterior shell and tip, an interior shell having its outer portion concentric with and approximating



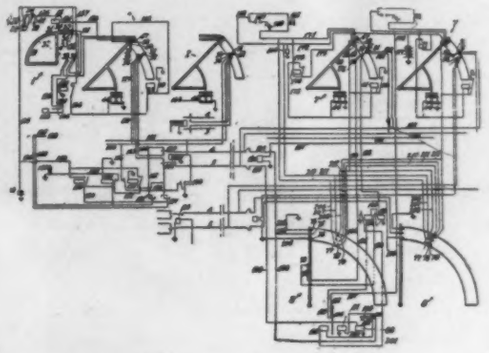
the shape of the outer end of the exterior shell, and having a cylindrical central opening, a pair of connected plungers fitting and reciprocal in the interior shell, and a convergent needle carried by the plunger and extending into the nozzle tip.

975,262. Gas-Filter. George S. Linn, Santa Barbara, Cal., assignor of one-half to Edwin S. Hicks, Santa Barbara, Cal. In a device of the class described, the combination with a cylindrical casing disposed on a horizontal axis and having drain openings at its lower side, of closing heads at opposite ends thereof, inlet and outlet pipes leading respectively from



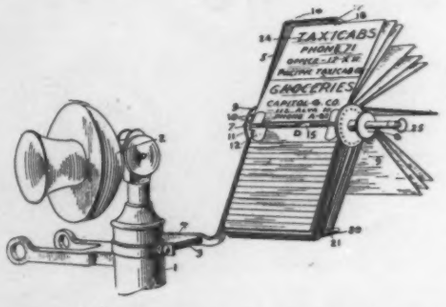
the heads, one of said heads having upon the inner side thereof, circumscribing the outlet pipe a transversely segmental strainer casing having a plane floor and arcuate upper wall concentric, with the wall of the cylindrical casing, the inner end of said strainer casing being disposed intermediately of the cylindrical receptacle, a screen member carried across said strainer casing spaced from the supporting heads, a second screen hinged to the opposite end of the strainer casing and adapted to close said ends, said plane floor having perforations therethrough and permeable material carried in the casing for collection of moisture in gases passing therethrough for drainage by gravity through the openings in said floor.

975,105. Semi-Automatic Telephone System. Charles R. Austin, Long Beach, Cal. A telephone system, comprising a central station, a plurality of sub-central stations, a plurality of subscriber's lines connected to each sub central station, each sub central station having automatic switch means responsive to selective impulses from the central station to connect one end of the subscriber's line to a line from the central station,



a plurality of selective impulse transmitters at the central station, each selective transmitter being adapted to send a selective series of impulses corresponding to one of the subscriber's lines at the sub-central station, and manual-switch means at the central station having an individual connection for each of the selective impulse transmitters, whereby the said manual switch means manually selects the selective impulse transmitter, and said transmitter automatically selects the subscriber's line.

974,957. Telephone-Directory. Wallace G. French, Oakland, Cal. In combination with a support provided with means for securing it to a stand or the like, upper and lower parallel members secured at one end to said support, the other ends of said members being free, a shaft rigidly secured at one end to said support and extending substantially



parallel with said upper and lower members, the other end of said shaft being free, a tube rotatably and removably mounted on said shaft, disks secured upon said tube, each having a circular series of recesses, memorandum cards and metallic clips secured upon adjacent corners of said cards and having reduced ends in said recesses, substantially as described.

INDUSTRIAL

MOTOR DRIVE IN A BOOKBINDERY.

The Williams Bookbinding Company of New York City in 1907 found itself seriously handicapped by an inefficient belt drive from the cellar source of power which supplied their two floors. In order to get better variable speeds and likewise do away with the loss of production from oil and grit falling from overhead shafting they took up the electric drive as a solution of their troubles.

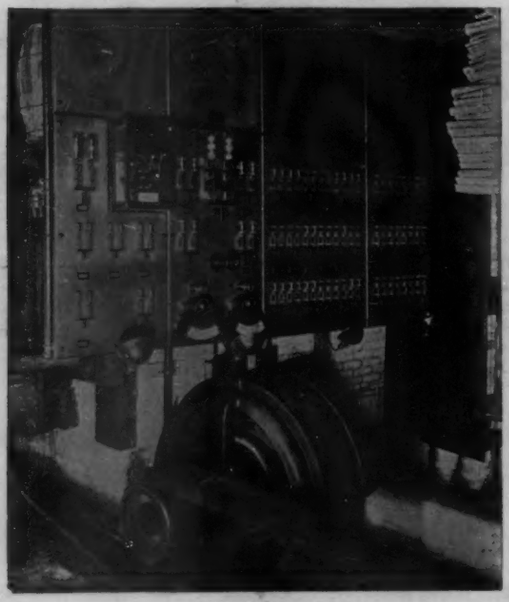


Fig. 1. 40 kw. Generator and Main Switchboard.

Fig. 2. General View of Fourth Floor.

Fig 4. Paper Cutter.

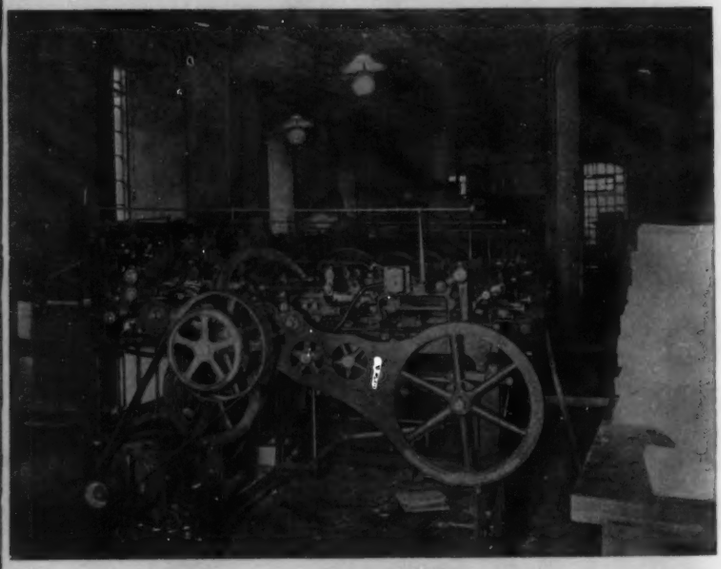


Fig. 3. A Group of Six Dexter Folders Fitted with Mechanical Feeders.

The generator is a 40 kw. 250 volt machine mounted on the ceiling and driven by shafting and belting from a slow speed Corliss engine in the basement. Directly underneath the generator, as shown in Fig. 1, is the main switchboard. The generator panel is provided with a main line switch, a 300 scale voltmeter, a 200 scale ammeter, a field rheostat controlling handle, and several smaller switches for the 230 volt lighting circuit. The panel to the extreme right is a feeder panel for the 230 volt lighting circuit and it also feeds the fourth floor distribution board shown in Fig. 2. A Thompson astatic totalling wattmeter is mounted on this panel. The two remaining panels serve as distribution boards for the lights and motors of the fifth or generating floor.

A battery of six Dexter folders with mechanical feeders is shown in Fig. 3. The motors for these folders are started and stopped by means of two-button push buttons, six of which are placed at different points about each machine, so that the attendant may stop or start the machine from any position. These push buttons control an automatic starter for the motor. A field rheostat is also installed, and by setting this the foreman can arrange for any speed, so that the

attendant need only operate the controlling buttons. The automatic starter, field rheostat, main line switch and fuses are mounted on a slate panel set up within the framework of the folder, but not visible in the illustration.

Fig. 4 shows a cutter, whose motor is started and stopped about once in every ten minutes. The apparatus is self-explanatory.

Fig. 5. Pasting Machine.

The makers of the pasting machine shown in Fig. 5 did not believe that this piece of apparatus could be operated by a motor because of the fact that it had to be stopped quickly and would require an unusually strong man on the brake. A motor, an automatic starter, and a dynamic brake made this machine manageable by a girl attendant, who needs only to push the control button.

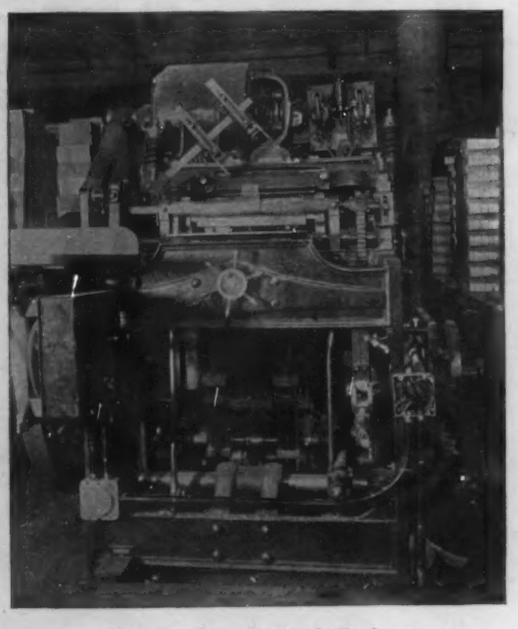


Fig. 6. Rounder and Backer.

A rounder and backer is a slow moving machine used for rounding the back of a book. As ordinarily equipped,, the electrical application consists of a hand operated rheostat, a motor, and a foot switch to open the holding coil of the rheostat when the brake is worked. When it is desired to reverse the machine, the fly-wheel is pulled back by hand. Fig. 6 shows an arrangement by means of which time is saved both in the frequent use of the hand starting rheostat and in the cumbersome method of pulling back the fly-wheel by hand. The reversing switch, when moved from the vertical, will cause the automatic starters to operate, thereby energizing the motor. When the foot brake is pressed down, the circuit will open, the operation being the same

Fig. 7. Gatherer.

when the machine is reversed. The attendant keeps his foot on the brake most of the time. A field rheostat enables the foreman to set the speed for the output desired; this may vary from 30 to 90 books an hour according to size, shape and weight of material.

A book is usually made up of from 25 to 60 sections which are gathered in proper order by a motor driven gatherer shown in Fig. 7, the operating buttons being located on the machine at the receiving end. The motor is mounted on pipe supports.

About 35 motors varying in size from ¼ h.p. to 5 h.p. are now in this plant. Small motors of one horse-power or less, operating machines which require practically no starting torque, are compounded and thrown across the line. These motors are started by 3-way snap switches which give full field before the armature is switched onto the line; this arrangement obviating considerable trouble from the blowing of fuses.

Nearly all motors larger than one horsepower are provided with automatic starting devices, the result of which is an increase of 15 per cent in the output for a given number of men and machines. This increase in production has not been due alone to the speeding up of various machines, but to the time saved through not having the employees concerned with starting the motors.

At first, when hand operated rheostats were used, the girl attendants would pull away from a rheostat handle when a spark occurred; several attempts usually being made before the lever was finally set on the holding coil. The male attendants, on the other hand, would hold the handle on a point until smoke came from the rheostat, when they would let the handle go and wait for the rheostat to cool. It was to eliminate these losses that the company installed automatic starting devices and the results have more than justified the expenditure.

Before the addition to the switchboard equipment of the totaling wattmeter mentioned previously, it had been the custom of the company and the owners of the building to arrive at an agreement as to the probable power requirements and to draw up a contract accordingly. The wattmeter

showed a 25 per cent smaller average load than that agreed upon and a corresponding reduction was made in the price for power.

It will be noted that some of the motors have to start under weakened field. To overcome this disadvantage 25 per cent extra capacity and compounding were added to the motors. With this addition, no trouble is experienced in starting up any position of weakened fields.

The electrical equipment of this plant is of General Electric manufacture throughout.

TELEPHONES FOR DISPATCHING TRAINS.

The telephone method of dispatching trains has lately been adopted on the Shasta Division of the Southern Pacific Railroad, where telephone circuits have been installed over 291 miles of road. The new method is being used over a 206 mile section of main line between Ashland, Oregon and Red Bluff, California, and a branch of 95 miles from Weed, California, to Klamath Falls, Oregon. The dispatcher is at Dunsmuir, California, which is 98 miles from Red Bluff, the southern terminal of the circuit. There are twenty-five stations on the entire circuit, twelve being between Dunsmuir and Red Bluff, nine between Dunsmuir and Ashland and four between Weed and Klamath Falls.

This entire circuit is composed of especially drawn 300 pound copper wire, metallic circuit. This telephone line goes through a mountainous region, and wire of extreme weight has been selected, not alone for conductivity but for tensile strength as well. This circuit during sixteen hours out of twenty-four is cut into two sections and during the third "trick" the entire circuit is operated by one dispatcher.

The apparatus for this dispatching system has been furnished by the Western Electric Company, which has made more than 90 per cent of the train dispatching telephones now in use in the United States. Passenger and freight trains on the Southern Pacific are equipped with portable telephone sets, enabling trainmen to get in touch with the dispatcher from any point along the road.

GREAT ELECTRIC DELIVERY SERVICE.

The recent electric delivery service installed by Gimbel Bros. of New York, shows a combination of hard-headed business economy, progressiveness, and a keen appreciation of the advertising value of swift, sure and silent delivery. Their initial installation covers a total of 66 vehicles, 36 of which are for small package delivery, and 30 for heavier service, ranging in capacity from two to five tons.

The entire line of vehicles was built by the Studebaker Company, and all are equipped with Westinghouse motors, controllers, main switches, charging plugs, and receptacles. The motors for the package delivery wagons are known as the Type V-20-A motor rated at 31 amperes, 50 volts, 1250 r.p.m. From this size the motors increase in size to the store truck which is equipped with two type V-30 motors rated at 80 volts, 35 amperes, 800 r.p.m. All motors are series wound, and all are provided with ball bearings. The vehicles are equipped with Westinghouse continuous torque metal drum series-parallel controllers, giving five speeds forward and five reverse.

Electric vehicles have now been in service long enough to pass the experimental stage and to demonstrate their great superiority over horse drawn vehicles and other tractors, especially for service in congested districts. From standpoints of economy, speed reliability under all conditions, durability, cleanliness, in fact from almost every conceivable standpoint the electrically driven delivery wagon has much the advantage.

In placing so large an order as that of the Gimbel Brothers, it was indicative of good business foresight to use the greatest care in selecting all vital parts of the equipment. Among these parts none was of greater importance than the motors and controllers; for successful operation of the vehicles these two parts must be of the greatest possible reliability and durability. They must be highly efficient, of maximum strength, and minimum weight; they must be built to withstand the most severe service conditions to which electrical apparatus can be subjected in the hands of unskilled operatives. The ordinary protection afforded by fuses or circuit-breakers is not desirable here, and moreover is not required, since the motors selected will take the full battery current without injury.

NEW CATALOGUES.

Compressed Air for Industrial Purposes is illustrated and described in Bulletin 4025 from the Allis-Chalmers Company.

Circular 114 from the D. & W. Fuse Co., Providence, R. I., is devoted to Subway Boxes of various types for exacting service.

Bulletin No. 4769, entitled "Train Lighting with G-E Mazda and Tantalum Lamps," should be of interest to all connected with this branch of transportation.

Bulletin No. 9 from the Bowie Switch Company, Lick Building, San Francisco, illustrates and explains the use of Kilarc high-tension switches and circuit-breakers.

National Metal Moulding Company of Pittsburg, Pa., have issued an attractive catalogue and price list of fittings for this "ideal method of metal-enclosed exposed wiring." Detailed illustrated instructions are given for its installation.

In Bulletin No. 4780, just issued by the General Electric Company, is illustrated and described the Gem lamp which has a higher economy and greater illuminating power than the carbon, but is, of course, less efficient than either the Tantalum or Mazda.

Ad. Book No. 21, just issued by the Westinghouse Electric & Manufacturing Company, Pittsburg, Pa., contains comprehensive, forceful advertisements of the company's general utility motor. The copy is intended to be of assistance to central station companies that are conducting campaigns to build up their day loads.

An interesting, well illustrated booklet has just been issued by the Westinghouse Electric & Manufacturing Company on the subject of Unit Switch Control. The circular, numbered 1189, explains the plan of operation of this type of control, shows complete wiring and piping diagrams, and discusses the details of the apparatus.

In Bulletin No. 4777, recently issued by the General Electric Company on the subject of "Building Lighting," many illustrations of both exteriors and interiors of buildings lighted by GE Mazda and Tantalum lamps are shown. In addition to these illustrations, there are data relative to the subject and illustrations of the complete lines of both types of lamp.

In Bulletin No. 4781, recently issued, the General Electric Company illustrates the series Mazda lamp, and offers considerable data, proving the advantages possessed by this lamp over the other incandescent lamps used for this purpose. The bulletin illustrates also various styles of fixtures used in connection with street illumination, and contains considerable data which will be of service to all interested in this subject.

The Westinghouse Electric & Manufacturing Company, of Pittsburgh, Pa., has just issued its Ad. Book No. 20, offering newspaper copy to the central stations that are booming electrical appliances. The book contains a complete collection of attractive and forceful ads, covering the Westinghouse Company's lines of toaster stoves, disc stoves, irons, luminous radiators, air heaters, bell ringing transformers, and Cooper Hewitt rectifiers.

NEWS NOTES

INCORPORATIONS.

SEATTLE, WASH.—The West Coast Light, Power & Water Company, capital $500,000, has been incorporated by Albert N. Moughin, Alfred P. Dobson and S. F. Bradbury.

IRONDALE, WASH.—Articles incorporating a monorail system have been filed at Olympia by Walter Strange, Homer C. Meyers, capitalized at $500,000. It is the intention of the company to begin the immediate construction of a monorail railroad connecting Port Townsend and this place.

FINANCIAL.

KINGSBURG, CAL.—A bond issue of $26,000 for water works and fire protection for this city has been authorized by a vote of 106 to 24.

CORNING, CAL.—At an adjourned meeting of the town trustees last week an ordinance was passed offering for sale the $70,000 bonds voted recently to build water and sewer systems.

PASCO, WASH.—The Council has passed an ordinance for the purchase of water rights from the Pasco Reclamation Company, the proposed price of which is $50,000. General city bonds in the denomination of $5000 each are to be issued to take care of the purchase price.

LOS ANGELES, CAL.—The Council has voted to accept a modified contract for the sale of the remaining $8,250,000 bonds to the syndicate headed by Kountze Bros. and A. B. Leach & Co. of New York, of which $2,270,000 are to be taken at once. Money will be spent mostly on steel siphons for the aqueduct.

VALE, ORE.—Sealed proposals will be received by the Common Council of the City of Vale, Malheur county, offering the purchase of bonds in the sum of $35,000 to be issued in any sum not less than $100, nor more than $1000, for the purpose of installing a flow line to furnish said city with a gravity system.

SALINAS, CAL.—At the meeting of the City Council this week plans will be completed by the municipal government for calling an election to bond the city to provide a municipally owned and operated gas, water and electric light plant. The cost of the proposed improvements will be in the neighborhood of $125,000.

TURLOCK, CAL.—A special election will be held in the city of Turlock on Monday, November 21, 1910, at which time will be submitted the question of issuing and selling bonds in the amount of $15,000 for the construction and completion of a more extensive water system, and also for the incurring a bonded indebtedness of $10,000 for the construction of and completion of a more extensive sewer system.

TRANSMISSION.

LOS ANGELES, CAL.—The Desert Power & Water Company, is doubling the capacity of its electric power plant at Kingman, Ariz., at a cost of about $75,000 and is extending one of its supply lines six miles making its system aggregate about 32 miles.

TACOMA, WASH.—Messrs. Savage & Nichols have been awarded the contract for the building of the upper portion of the Nisqually power system. The work on which contracts have been let is the building of a dam in the Nisqually river and of a 10,000 foot tunnel. Chief Engineer Hamilton F. Gronen is of the opinion that the city would save 15 to 20 per cent on $300,000 or $400,000 worth of machinery if it should buy the machinery direct from the manufacturers. Commissioner Nicholas Lason of the department of light and water is anxious to buy the machinery separately and especially to let a contract for the transmission line.

WALLA WALLA, WASH.—A. S. Grenier of Portland, manager of the Pacific Power & Light Company announces that the company plans to build a power transmission line from here to Freewater country, which will furnish power for pumping water for irrigation of 11,000 acres.

SPOKANE, WASH.—D. L. Huntington, president of the Washington Water Power Company, announces that the company has purchased 7000 acres of land north and west of the Nine Mile, on the Spokane river and has about completed preliminary negotiations for building an electric power plant.

RED BLUFF, CAL.—Three deeds have been filed which conveyed to the Northern California Power Co. the right to construct, use and maintain ditches, flumes and tunnels, power lines and wagon roads across the lands of Elmer L. Fullwright and Willis H. Stone. Provisions are made in the deeds requiring the company to furnish gates so water can be used for stock and to provide adequate protection against the injury of stock. The lands are about 18 miles northeast of Red Bluff and evidently the lines to be constructed are from the south fork of Battle Creek.

WILLOWS, CAL.—A new electric company, which is being formed with C. R. Wickes as one of the prime movers and a number of local people as stockholders, has applied to the trustees for a franchise for a line through the streets of Willows, asking that the franchise be offered for sale. The company expects to get power from the Sacramento Valley Power Company, the latter's line now being three miles from Orland. If the local company secures the franchise its representatives promise to furnish the citizens of Willows with light and power within six months.

WONDER, NEV.—The survey of the electric power line to Wonder has been completed and contracts for its construction are to be entered into immediately. Some of the materials are already on the ground. The line is to be constructed by the Mono Electric Power Company from Lucky Boy to Wonder, a distance of 75 miles, and is to be completed by February 15, 1911. Current at a voltage of 60,000 is to be delivered to mining companies and other consumers for light and power. The company generates its power in Mono county in the Sierra Nevadas, and has had some trouble in getting a permit to cross a National Forest with its pipe line.

OROVILLE, CAL.—Filings have been made on large quantities of water to be taken from the Middle Fork, Falls river and Bear Creek in that section. A power house to generate electricity will be erected on a high hill near the junction of the Middle Fork and Fall river. Paul Rohrig has filed upon 20,000 inches of water to be taken from the Middle Fork of the Feather river near the junction with Bear Creek, in Plumas county, and to be conveyed by a 16-foot ditch for a distance of 22 miles to the junction of the Fork and Falls rivers. The appropriation states that a concrete dam 25 feet high, 10 feet through and 200 feet long is to be built at the point of diversion of the stream.

BAKERSFIELD, CAL.—Work on the new sub-station for the San Joaquin Light & Power Company at Twenty-fourth street and Union avenue is being completed as rapidly as possible and the officials of the company expect to have the plant ready for operation this week. Although neither roof nor sides have been put on the building, the machinery has been

partially placed in position and the walls and roof will be erected later. One 750 kw. generator and Curtiss turbine engine have been set up together with all of the boilers and other paraphernalia for running the big generator, which will be started about Tuesday and will supply an additional 1000 h.p. service to the city. Within about two months, another 200 kw. generator will be installed at the sub-station. The big machine was made by the General Electric Company and is being shipped to this city direct from the factory in the East.

OROVILLE, CAL.—One of the greatest projects ever attempted in California is to follow the absorption of the Great Western Power Company by the Pacific Gas & Electric Company, and if carried out successfully one of the biggest power plants in the country will result. It is projected to dig a tunnel four miles long from Big Bar to Bartel's Bar on the Feather river, and to get a fall that will generate as much electricity as does the Big Bend plant of the Great Western Power Company. A surveying crew under the leadership of L. P. Cornell is now engaged in surveying the proposed tunnel. It is estimated that the work will cost $10,000,000. If found feasible the work will be rushed to completion, as it is expected the Western Pacific Company may soon be a big consumer of power, as the Gould line officials are now experimenting with electric locomotives with the idea in view, it is said, to operate the Western Pacific trains over the mountains and across the deserts by electricity.

TRANSPORTATION.

LONG BEACH, CAL.—The Pacific Electric Company has been granted a franchise to lay a branch line on Riverside drive near Sixth street to connect the Union oil plant with the main line.

PRINEVILLE, ORE.—F. T. Hurlburt, a heavy stockholder in the Cline Falls Power Company, was in Prineville, after transferring the company's property at Cline Falls to a Redmond syndicate. It is understood that the purchasers had in view the construction of an electric railroad between Redmond and Prineville.

LOS ANGELES, CAL.—A franchise for the Pacific Electric Company on San Pedro street has been asked of the Council. It is proposed to run on that street and into the Pacific Electric station the interurban cars operated through the northern part of the city. The plan has been to have these cars enter the Pacific Electric building from the rear and on the level of Los Angeles street, which is considerably lower than Main street.

SAN FRANCISCO, CAL.—S. N. Griffith has been here to confer with the Western Electric Company on specifications for the electric installation work that will be necessary for furnishing power for the Fresno-Clovis electric road. He says that he will apply for a franchise from Fresno for the railroad which he proposes to build between Fresno and Clovis at the next regular meeting of the board, two weeks hence. The application for the franchise will not involve freight rights through Fresno, as these rights are no longer granted. Instead Mr. Griffith proposes to transfer his freight from the interurban line to the Santa Fe at a point near that city.

OAKLAND, CAL.—The Southern Pacific Company has filed a petition for a renewal of the Seventh street franchise, which expires November 11, 1911. The proposed line will be operated as an electric street railway and will be part of the gridiron system of electric suburban lines now being constructed by the company throughout the county. The petition was signed by the required two-thirds of the property owners along the right of way, which extends from its present western terminus at the Oakland mole to its eastern terminus at Fallon street. The life of the grant asked for is fifty years. The matter will come up for hearing on December 5.

LOS ANGELES, CAL.—The building of a municipal electric railway between the business center of Los Angeles and its harbor at San Pedro, on which individuals, firms or corporations may operate their own cars under the supervision of a commission, and upon the payment of proper tolls, is urged by Joseph Simons, president of the Simons Brick Company. He holds that the city should begin the construction of a steel road, and have it ready by the time power from the Owens river becomes available. The road could come into the city along the river bed, and have lateral lines, if desirable. With such a line in operation, a car could, he says, be sent to San Pedro and return, in connection with other cars, at a cost not exceeding $3.

SACRAMENTO, CAL.—War has been declared here by the Southern Pacific against the Northern Electric. The Southern Pacific has a band of men on guard at the intersection of Front and X streets in an effort to keep the Northern Electric from crossing the Southern Pacific tracks with its freight line, which, to hold the company franchise, must be completed by the 15th of November. To block the trolley road going across the steam tracks the Southern Pacific has had flat cars removed from trucks and spiked on the spur where the new road desires to cross. Old metal, pieces of machinery that weigh many tons and various other kinds of obstructions have been placed on the spot and a couple of engines are moving to and fro along the disputed territory to prevent encroachments by the enemy. The Northern Electric is building its freight line down X street and must cross the Southern Pacific to get on Front street in order to get at the new Northern Electric bridge building across the Sacramento river at the foot of M street. No move was made by the Southern Pacific until the trolley line reached the point of crossing.

ILLUMINATION.

TURLOCK, CAL.—The La Grange Water, Light and Power Company has taken over the holdings of the Turlock Electric Company.

PASADENA, CAL.—Manager Koiner of the municipal lighting department has been granted permission to purchase material and supplies amounting to $2850.

TACOMA, WASH.—The Snohomish County Commissioners have granted to L. F. Query a franchise to operate an electric light system at Stanwood, the plant to be placed in operation within a short time.

EUGENE, ORE.—H. H. White, manager of the Byllesby Company, and his engineer, O. T. Lawson, have completed arrangements for the erection of their proposed gas plant and other buildings here and for a power plant at Springfield, Ore., to cost about $350,000.

MODESTO, CAL.—The City Trustees have purchased the material and supplies for the Wisecarver addition street lighting system. Proposals having been advertised for, two firms, the Westinghouse Co. and the General Electric Co., bid for the electrical supplies. The General Electric Company's bid of $404.90 was accepted. This company submitted the only bid for wire. The contract for 14,000 feet of No. 8 wire at $172 was awarded them.

TELEPHONE AND TELEGRAPH.

BEND, ORE.—The Pioneer Telegraph & Telephone Company has begun installation of a telephone line from Rossland to Crescent.

SANDPOINT, IDAHO.—A crew for the Bell Telephone Company has started the construction of a telephone line at Bonners Ferry and are working north. The line will connect this place with Cranbrook, B. C.